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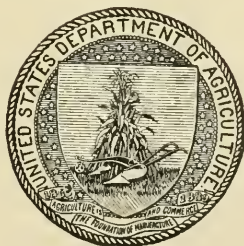
BUREAU OF PLANT INDUSTRY—Circular No. 120.

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

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Issued April 5, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

1809
#120-132

BUREAU OF PLANT INDUSTRY.

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[Cir. 120]

TESTING CULTURES OF NODULE-FORMING BACTERIA.¹

By KARL F. KELLERMAN, *Physiologist in Charge of Soil-Bacteriology and Plant-Nutrition Investigations.*

INTRODUCTION.

The importance of leguminous crops in maintaining soil fertility or in rejuvenating overcropped and worn-out fields has long been recognized by practical farmers. Critical investigations carried on both in the laboratory and in the field have shown that this method of improving soil conditions is dependent chiefly upon the simultaneous development of a leguminous crop and the variety of bacteria which can produce root nodules and fix atmospheric nitrogen in suitable form for plant food.

Although these nodule-forming bacteria are widely distributed in nature, there are regions where they are lacking, and they should be artificially introduced into the soil in these regions. This may be accomplished either by transferring from 200 to 500 pounds of soil per acre from a field where the leguminous crop shows abundant root nodules to the new field where the same legume is to be planted, or by the application of artificially prepared cultures of bacteria to the seed before planting or directly to the field itself. Though inoculation by the pure-culture method has proved less universally successful than the soil-transfer method, the artificial cultures possess certain important advantages, especially the greater ease of their transportation and application, as well as their freedom from danger of introducing weeds or plant diseases.²

VARIATION IN INOCULATING POWER.

A plausible explanation for the occasional failure of cultures of *Bacillus radicicola* to properly inoculate a crop is that the bacteria, though able to grow vigorously in the culture medium, have actually deteriorated in the essential quality of being able to infect the leguminous roots and to produce nodules. Testing the cultures at frequent intervals on potted plants in greenhouses or on small plats

¹ Issued Apr. 5, 1913.

Messrs. F. L. Goll and L. T. Leonard, scientific assistants, have assisted in working out the details of construction of the testing apparatus and its utilization in the laboratory.

² These facts are discussed in more detail in previous publications of the Bureau of Plant Industry.

of leguminous crops in the field has been relied on to show which strains of bacteria had but a moderate or low inoculating power and which were most efficient. While these tests were useful, they were seldom entirely satisfactory, due to the frequency of chance inoculation of plants in either plats or pots by worms, insects, dust, and unsterilized water.

It is obvious that tests of cultures should be carried on under sterile conditions, which should at the same time resemble as nearly as possible the soil and climatic conditions of nature. Although nodules have been produced frequently by growing sterilized inoculated seedlings upon sterilized agar media in flasks,¹ this method of testing cultures is undesirable on account of abnormal conditions. The use of jars containing small quantities of sterilized soil has also been attempted,² but without success. During the last year numerous experiments have been conducted with a special type of jar supplied with a tubular neck near the bottom, and it is believed that with this simple apparatus accurate tests of the inoculating power of the bacteria may be made at frequent intervals.

TESTING THE INOCULATING POWER.

A jar of the type shown in figure 1 is charged first with a layer of cinders or broken marble and then with coarse sand moistened with Sachs's solution lacking in nitrogen compounds; the side tubulature is plugged with cotton wool; a narrow layer of cotton wool is drawn around the jar near the top; and over this a snugly fitting beaker is carefully slipped. The jar is now sterilized in an autoclave at 20 pounds pressure for 30 minutes and is ready for use. To avoid cracking the jar the autoclave must be raised to the sterilizing temperature very gradually, and at the end of the sterilizing period the temperature must be allowed to fall very gradually. At least three hours should be consumed in this process. By using ordinary bacteriological precautions it is possible to introduce sterilized seeds through the side tubulature and later inoculate them, with practically no danger of contamination. Black paper is then wrapped around the lower part of the jar to protect the growing roots from light. A slight circulation of air results from the processes of respiration and photosynthesis within the jar, since both top and bottom offer opportunity for the passage of air through the cot-

¹ Harrison, F. C., and Barlow, B. The nodule organism of the Leguminosae—its isolation, cultivation, identification, and commercial application. *Centralblatt für Bakteriologie* [etc.], Abt. 2, Bd. 19, No. 7/9, p. 264-272, 1907.

Kellerman, Karl F. The present status of soil inoculation. *Centralblatt für Bakteriologie* [etc.], Abt. 2, Bd. 34, No. 1/3, p. 42-50, 1912.

² Wilson, J. K., and Harding, H. A. Method of keeping bacteria from growing plants. *Science*, n. s., v. 33, no. 849, p. 545, 1911. (Abstract.)

ton wool. The leguminous plants grow well, and if the culture used for inoculating is in proper condition normal nodules are soon formed.

By this procedure it has been possible to distinguish sharply between the inoculating power of apparently identical strains of bac-



FIG. 1.—Jars for testing the inoculating power of different strains of *Bacillus radicicola*. In the jar at the right are inoculated garden-pea plants, while at the left are uninoculated ones, each 3 weeks old.

teria, and in future all stock cultures intended for distribution by the Office of Soil-Bacteriology and Plant-Nutrition Investigations to farmers and other experimenters in the United States will be tested in this manner.

THE WORK OF THE SAN ANTONIO EXPERIMENT FARM IN 1912.¹

By S. H. HASTINGS, *Farm Superintendent, Office of Western Irrigation Agriculture.*

INTRODUCTION.

The work of the San Antonio Experiment Farm is devoted to the investigation of agricultural problems peculiar to large areas in the southwestern United States, where the conditions of soil and climate are similar to those at San Antonio. The more important lines of work carried on are tillage and rotation experiments; breeding, variety testing, and different planting methods for cotton; variety



FIG. 1.—View showing the buildings on the San Antonio Experiment Farm.

testing of grain sorghum and broom corn; corn breeding and variety testing; a few forage-crop experiments; variety testing of peaches, plums, apricots, persimmons, grapes, walnuts, almonds, and other fruits, including Chinese dates. In addition to such horticultural work as is mentioned above, much attention is being given to finding stocks better adapted to the local conditions than those now used.

¹ Issued Apr. 5, 1913.

The San Antonio Experiment Farm comprises about 125 acres of land situated about 6 miles south of San Antonio, Tex. The tract belongs to the city of San Antonio and is leased to the Department of Agriculture. About 80 acres of the land are under cultivation, and 6 of these are irrigated. The farm is equipped with the buildings (fig. 1) necessary for storage, laboratory, and office purposes and for employees' quarters. The experiment farm is under the direction of the Office of Western Irrigation Agriculture of the Bureau of Plant Industry and is maintained from the funds of the Department of Agriculture. Previous general reports on the work of the farm were published in 1908 and 1909 as Bureau of Plant Industry Circulars Nos. 13 and 34.

and sorghum, were good. The preceding winter was one of unusual severity and the amount of winter rainfall was somewhat above the normal. From June 23 until late in September practically no rain fell, the total precipitation for the months of July and August being only 0.33 inch. This continued drought of nearly three months cut the cotton crop short. The spring was late and consequently the corn and other early-planted crops were somewhat late in maturing. The total precipitation for the year, as measured at the farm, was 26.37 inches,¹ which is practically the normal for this section, but somewhat higher than the mean annual rainfall for the period 1907 to 1912, inclusive.

The meteorological observations at the experiment farm are made in cooperation with the Biophysical Laboratory of the Bureau of Plant Industry. Table I shows the summaries for 1912 compared with the means for the six-year period 1907 to 1912, inclusive.

TABLE I.—*Summary of meteorological observations at the San Antonio Experiment Farm, 1907 to 1912, inclusive.*

PRECIPITATION (INCHES).

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average, 6 years, 1907 to 1912, inclusive.....	0.54	2.23	1.66	2.96	2.47	1.28	1.54	1.63	1.15	2.60	2.52	1.88	22.46
For the year 1912....	.31	6.21	2.30	2.04	1.64	3.42	.08	.25	1.53	2.92	1.76	3.91	26.37

EVAPORATION (INCHES).²

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average, 6 years, 1907 to 1912, inclusive.....	2.72	3.12	4.68	5.32	6.63	8.40	8.69	9.39	7.31	5.23	3.21	2.38	67.07
For the year 1912....	2.35	3.35	3.05	3.88	7.39	7.02	10.59	10.65	8.52	5.41	3.23	1.83	67.26

DAILY WIND VELOCITY (MILES PER HOUR).³

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1911, highest.....	10.4	15.9	9.0	10.6	9.2	11.9	12.5	12.1	6.6	8.5	9.5	7.2	.....
1912, highest.....	8.2	11.2	6.4	6.0	5.9	8.4	7.3	7.6	6.5	7.6	5.7	8.0	.....
1911, lowest.....	1.12	1.45	2.24	3.28	2.17	2.34	2.82	1.82	1.98	.86	1.06	.97	.....
1912, lowest.....	.77	.62	.86	.84	1.22	1.08	1.38	2.30	1.42	.89	.76	.81	.....
1911, average.....	5.60	7.02	5.20	6.10	5.60	6.40	6.86	4.59	3.91	3.76	3.24	3.36	.....
1912, average.....	3.16	4.00	3.50	2.68	3.23	2.92	4.27	4.83	3.75	3.84	2.68	2.80	.....

¹ The rainfall in the city of San Antonio in 1912, as reported by the United States Weather Bureau, was 23.7 inches, which was 3.2 inches below the normal.

² The evaporation measurements missing are as follows:

1909.—April, 2 days; June, 3 days; July, 6 days; August, 1 day; November, 1 day.

1910.—January, 7 days; February, 2 days; June, 3 days; July, 5 days; October, 4 days; December, 3 days.

1911.—April, 1 day; July, 2 days.

1912.—February, 2 days; April, 1 day; December, 2 days.

³ Wind velocities are reported for the years 1911 and 1912 only.

TABLE I.—*Summary of meteorological observations at the San Antonio Experiment Farm, 1907 to 1912, inclusive—Continued.*

TEMPERATURE (°F.).

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for period.
Absolute maximum, 6 years, 1907 to 1912, inclusive.....	88.5	87.0	95.0	102.0	103.0	108.0	108.0	105.0	104.0	98.0	86.5	82.0	108.0
Absolute maximum, 1912.....	84.0	78.5	82.0	90.0	103.0	100.5	105.0	104.0	101.0	94.0	84.0	74.0	105.0
Absolute minimum, 6 years, 1907 to 1912, inclusive.....	12.0	13.0	34.0	38.0	39.0	56.0	64.0	64.0	41.0	32.0	15.0	17.0	12.0
Absolute minimum, 1912.....	16.5	16.0	34.0	38.0	47.0	59.0	66.0	68.0	54.5	51.0	25.0	25.0	16.0
Mean, 6 years, 1907 to 1912, inclusive.....	54.1	51.7	65.0	68.6	75.2	82.7	85.2	85.3	80.3	69.6	59.6	50.2	69.2
Mean, 1912.....	46.6	49.9	55.4	67.4	76.5	77.8	85.1	86.8	82.0	71.8	59.4	48.6	67.3

KILLING FROSTS.

Years.	Last in spring.		First in autumn.		Length of frost-free period.
	Date.	Minimum temperature.	Date.	Minimum temperature.	
		°F.		°F.	Days.
1907.....	Feb. 8	29	Nov. 12	32	277
1908.....	Feb. 20	24	Nov. 14	29	268
1909.....	Feb. 25	30	Dec. 6	31	284
1910.....	do.....	26	Oct. 29	32	246
1911.....	do.....	29	Nov. 13	31	261
1912.....	Feb. 27	30.5	Nov. 2	29.5	245

ROTATION AND TILLAGE EXPERIMENTS.¹

The rotation and tillage experiments, which are conducted on 82 plats of one-fourth of an acre each, were continued as previously, except that milo was substituted for corn on four plats and for oats on one plat.

The results of the rotation experiments indicate that crop rotation is an important factor in crop production in this section of Texas, the yields of crops grown in a suitable rotation being on the whole uniformly higher than when grown continuously on the same land. The average yields of all crops except cotton were the highest of any year since the work was started in 1909.

Table II gives the crops in the rotation experiments, the number of plats planted to each crop in 1912, the average yields per acre, and the highest and lowest yields per acre in 1912.

¹ These experiments are under the direct supervision of Mr. C. R. Letteer, assistant.
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TABLE II.—Average yields per acre of crops in the rotation experiments, San Antonio Experiment Farm, 1912.

Crop.	Average yield, 1907 to 1911, inclusive.	Yield in 1912.			
		Number of plats.	Average.	Highest.	Lowest.
Corn.....bushels..	14.6	26	34.1	42.3	24.3
Dwarf milo.....do.....	.....	5	40.0	52.0	32.5
Oats, grain ¹.....do.....	6.5	10	26.75	37.0	19.1
Cotton ².....pounds..	585.3	25	621.5	818.0	448.0
Sorghum: ³					
4.1 foot drills.....tons..	4.86	5	4.03	4.28	3.82
8-inch drills.....do.....	2.06	3	4.68	5.49	4.16
Oats, hay ¹.....do.....	.83	1	2.82	3.09	2.53

¹ No oat yields in 1907 and 1908.² Seed cotton.³ Sorghum not planted in 8-inch drills in 1908.

MANURING.

The effect of barnyard manure on crop yields in the rotations was more noticeable this year than ever before. The average yield of corn from all plats where manure was applied at some time during the course of the rotation was slightly greater than the average of corn plats in corresponding rotations not manured. The same was true of cotton, but manuring decreased the yield of oats for grain very noticeably. The oats on plats which had been manured grew very rank and lodged much more than on plats which had not been manured. The excessive vegetative growth and consequent lodging probably account largely for the decreased yield of grain.

While the results indicate the value of barnyard manure, the difference in favor of manure is much less on crops grown in a rotation than where grown continuously on the same land and manured each year. (See figs. 3 and 4.)

Table III gives the yields for 1912 and the average yields for 1910, 1911, and 1912 of crops grown continuously on the same land manured¹ each year compared with plats not manured.

TABLE III.—Yield² for 1912 and average yields for 1910, 1911, and 1912 of crops on manured and unmanured plats planted continuously to the same crops at the San Antonio Experiment Farm.

Crop.	Manured.		Not manured.		Difference in favor of manuring.	
	Average, 1910 to 1912.	1912.	Average, 1910 to 1912.	1912.	1910 to 1912.	1912.
Corn.....	15.9	30.5	11.6	26.6	4.3	3.9
Dwarf milo ³.....	.....	52.0	.....	32.5	.....	19.5
Cotton.....	455.3	572.0	397.3	474.0	58.0	98.0

¹ The manure is applied at the rate of about 15 tons per acre.² Corn and milo in bushels per acre; cotton in pounds of seed cotton per acre.³ The plats from which dwarf milo yields are given had previously been planted to corn for three years.

SUMMER FALLOWING.

Three years' results have now been obtained from the tests in summer fallowing land for corn, oats, and cotton. As in 1911, the yields of crops on land summer-fallowed the previous season were generally low, corn yielding at the rate of 24.7 bushels per acre, as compared with the average of 34.1 bushels per acre on the 26 plats in the rotation experiments. The corn on the summer-fallowed plat yielded the lowest, save one, of any of the 26 plats.

Cotton on summer-fallowed land yielded at the rate of 448 pounds of seed cotton per acre, as compared with an average of 621.5 pounds per acre on the 25 plats of cotton, giving the lowest yield of the 25 plats.



FIG. 3.—Cotton on plat B 5-3, land continuously cropped and not manured. This plat has yielded an average of 397 pounds of seed cotton per acre during the past three years. Compare with figure 4. (Photographed June 26, 1912.)

Oats for grain on a fallowed plat yielded at the rate of 37 bushels per acre, the highest yield obtained from the 10 plats of oats. The average yield from 10 plats was 26.75 bushels per acre. While the oats on summer-fallowed land yielded somewhat higher than the others, the increase was not sufficient to indicate that summer fallowing is a desirable practice under the conditions at San Antonio, even for oats.

SUBSOILING.

Subsoiling tests have been a rather important part of the rotation and tillage experiments. The results have been summarized and published in Circular No. 114 of the Bureau of Plant Industry.

The results from subsoiling in 1912 were corroborative of those of previous years, namely, that subsoiling does not materially increase the yields of crops, and in many instances decreases the yields, and that, owing to its being an expensive operation, it can not be recommended as a regular farm practice in connection with corn, oats, and cotton in the San Antonio region of Texas.

ROOT-ROT.

Root-rot, a fungous disease of plants,¹ is doubtless one of the most serious diseases with which farmers have to contend in the Black Lands of Texas. It affects such crops as cotton, cowpeas, and alfalfa,



FIG. 4.—Cotton on plat B 5-4, land continuously cropped and fertilized each year with barnyard manure. This plat has yielded an average of 455 pounds of seed cotton per acre during the past three years. Compare with figure 3. (Photographed June 26, 1912.)

but does no perceptible damage to plants belonging to the grass family, such as corn, oats, wheat, etc. In many cotton fields it causes the premature death of a large proportion of the plants. It was observed in 1912 that in a number of the rotations with cotton and corn the root-rot was much more widespread and did more damage to the cotton on plats which were spring-plowed than on plats which were summer or fall plowed. The same condition was apparent in 1911. It was also observed in 1912 that where cotton was grown in rotation with corn or oats the damage due to root-rot was much less noticeable than on plats continuously planted to cotton.

¹ This disease is caused by *Ozonium omnivorum*. For an account of the disease and methods of lessening its damage, see the paper entitled "The control of Texas root-rot of cotton," in Bureau of Plant Industry Bulletin 102.

HORTICULTURAL WORK.¹

THE MEXICAN SEEDLING PEACH.

The Mexican seedling peach trees² bore a heavy crop of fruit, and the early prospects were good that more data on the comparative merits of different trees might be secured. The earlier ripening trees gave a heavy yield of good fruit, but the continued drought of midsummer damaged all the peaches from the later maturing trees, making the tests with these trees nearly worthless. Nearly all the trees bore an exceptionally heavy crop, but they were not able to hold the fruit through such a long period of drought.

The trees are becoming overcrowded, owing to their size and close planting, bringing out the point that to obtain the best results the distance between the trees will have to be greater than is ordinarily adopted in more humid sections. The trees were planted 16 feet apart, but it is now apparent that better results would be secured if they were 22 feet apart.

The Office of Foreign Seed and Plant Introduction put in 324 buds from what were considered the best 9 trees of the Mexican seedling orchard. These budded trees are to be distributed to cooperators in southwest Texas to test their value under varying conditions.



FIG. 5.—English walnut grafted on native Texas black walnut in February, 1912. (Photographed August 28, 1912.)

¹ The horticultural experiments were under the direct charge of Mr. R. E. Blair, scientific assistant.

² The seed from which these trees were produced was collected in Mexico by Mr. Gilbert Orderdonk, under the direction of the Office of Foreign Seed and Plant Introduction. They are listed under S. P. I. Nos. 9320 and 9321.

OTHER PEACH VARIETIES.

In the variety peach orchard on Field A1, where there are 35 varieties of peaches, set out in 1906, an unusually heavy crop of fruit set. Even the northern peaches in most instances were heavily loaded for the first time in the history of the orchard. This should not be taken as an indication that this class of peaches is adapted to these conditions. Those belonging to the South Chinese type are the most reliable bearers. Of the varieties on trial the following have proved to be the best: Pallas, Honey, Imperial, and Triana. The wild peach from China (*Amygdalus davidiana*) is proving to be exceptionally good for peach stock, but there is difficulty in securing seed, as thus far it has not fruited here, with the exception of two fruits which ripened in 1912.

PLUMS.

The tests of plums include 16 varieties that have been under trial since 1906. The tests so far conducted indicate that the plum is probably the most reliable fruit for the San Antonio section. The American-Japanese hybrids bear somewhat more heavily than the pure Japanese sorts. The plums that have proved the best adapted to the conditions at San Antonio are the Gonzales, Burbank, Wickson, Terrel, El Paso, and Transparent.



FIG. 6.—Xenia grape grafted on native mustang grape in February, 1912. (Photographed June 28, 1912.)

NATIVE TREES AND SHRUBS.

Much work has been done on the domestication of native trees and shrubs suitable for use as grafting stock (fig. 5) or for crossbreeding.

Hybridization and grafting work has been done on the peach, plum, persimmon, and grape. Successful crosses between the native *Prunus texana* and the peach and plum have been made. The grafting of the better types of grapes on the native mustang grape has been done successfully (fig. 6). Some attention is also being given to grafting the English walnut on the native black walnut.

PERSIMMONS.

The propagation of persimmons has been tried, a special effort being made to utilize as a stock the native Texas persimmon (*Diospyros texana*), which grows so abundantly and persistently on the semiarid lands of western Texas and in the limestone canyons. This tree has long been regarded as a probable stock for the Japanese persimmon, but until recently it was impossible to produce a union. Successful results have lately been accomplished by inarching with *Diospyros texana* seedlings small enough to be handled in pots. In this method of inarching, the small native seedling is transferred to a paper pot after most of the soil has been removed from the roots, and the pot is filled with sphagnum. It is necessary that the pots be small and light, for under normal summer conditions the wind would prevent securely fastening a heavy pot in position long enough to permit the formation of a union. The stock and scion will commonly unite in about 30 days, but as the persimmon grows rather slowly even more time is desirable. Until this method was devised, no successful *Diospyros kaki* plants had been produced on *D. texana* stock. A few crown grafts were made to start, but no others. Budding has been attempted repeatedly by shield, patch, flute, and ring methods, with no success whatever. The following combinations have been successfully accomplished here by the inarch method described:

D. kaki on *D. texana* stock.

D. virginiana on *D. texana* stock.

D. texana on *D. kaki* stock.

D. texana on *D. virginiana* stock.

A small planting of varieties of Japanese persimmons worked on the native stock is to be made under dry-land conditions as soon as the trees can be propagated. Several have already been set to orchard positions. As most species of the Japanese persimmon suffer from chlorosis on the soils of the San Antonio region, it is believed that the use of this resistant stock may be a remedy for this trouble unless the scion proves to rapidly outgrow the stock.

ORNAMENTAL PLANTS.

Ornamental trees and shrubs suitable for the San Antonio section have been tried in large numbers. Particular attention is also being given to native trees and shrubs not already known or whose desirable qualities are not fully appreciated. In addition to the native trees and shrubs, about 100 varieties of roses and a collection of bamboos, palms, yuccas, agaves, and many others have been assembled.

FORAGE CROPS.

The results of all the forage-crop experiments conducted at the farm from 1908 to 1912, inclusive, have been assembled and published as Circular No. 106 of the Bureau of Plant Industry. This circular contains an extensive discussion of the results with the forage crops tested during the past five years. For this reason, only brief mention will be made here of the main features of the work in 1912.

Among the more conspicuous new forage crops that are particularly well adapted to the section may be mentioned Canada field peas and Sudan grass. So far Canada field peas have given a higher hay yield than oats, and apparently there is at least one variety that will stand nearly, if not quite, as much cold. Last winter there were on trial three lots, known as S. P. I. Nos. 30307, 18806, and 30134. During the winter there was a minimum temperature of 15° F. Nos. 30307 and 18806 were almost completely killed out, but, while the plants on the other planting (No. 30134) were killed nearly to the ground, new growth was put out and a grain yield of 14 bushels per acre was obtained. As a winter cover crop this is the most promising that has been tested.

Excellent results were obtained with Sudan grass in both 1911 and 1912. The yield of Sudan grass in 1912 was 5.66 tons per acre, based on the weights from a one-tenth-acre plat. Sorghum planted in the same way on the rotation fields gave a yield of 4.68 tons per acre.

A rate-of-seeding test consisting of seven one-tenth-acre plats of Sumac sorghum in 8-inch drills was conducted, as there is a variance of opinion among farmers as to the best rate, quality of forage and yield considered. The rates varied from 26 to 174 pounds per acre. The highest yield was obtained from the plat seeded at the rate of 88 pounds per acre, or slightly more than 1½ bushels. The quality of the forage was apparently equal to that produced by the heavier seedings and better than that in the thinner seedings.

Japanese sugar cane, which has been grown here for the past three seasons, gave a yield in 1912 of 13.08 tons per acre, the average yield for the past three years being 12.84 tons per acre. This crop is grown under irrigation.

VARIETY TEST OF COTTON.¹

A variety test of cotton was conducted with seven varieties and five selections of Triumph. Sixteen-rod rows of each variety were planted in triplicate. Table IV gives the results of the test.

TABLE IV.—Yields obtained in a variety test of cotton at the San Antonio Experiment Farm, 1912.

Variety.	Seed cotton per acre.	Percentage.	
		Lint.	Stand. ¹
	<i>Pounds.</i>		
Vergatus ²	735	32.4	100
S. A. 1,000 (Triumph).....	635	35.5	90
Roundnose.....	580	37.6	97
S. A. 920 (Triumph).....	580	37.8	89
Lone Star.....	525	34.2	78
Rowden.....	525	32.8	89
Triumph, general seed.....	520	37.2	93
Durango.....	496	27.8	87
Triumph, 152.....	480	37.9	87
Triumph, Mebane.....	480	38.2	94
Acala ³	410	35.7	80
Saunders No. 2.....	335	34.0	69

¹ Percentage of stand determined from an actual count of the plants in each row.

² Lint very short.

³ Lint but little better than Triumph.

As is shown, the Vergatus gave the highest yield, but the lint was very short, making it an undesirable variety.

GRAIN SORGHUMS.

The experiments in grain sorghums reported on last year² were continued. Both variety and time-of-planting tests were made. Table V gives the average yields of the varieties for three plantings.

TABLE V.—Yields obtained in a variety test of grain sorghum at the San Antonio Experiment Farm in 1912.

Variety.	Bushels per acre.	Variety.	Bushels per acre.
Dwarf milo.....	50.5	White sorghum.....	25.4
Standard milo.....	46.8	White durra.....	22.6
Blackhull kaoliang.....	36.5	Standard Blackhull kafir.....	19.9
Sudan durra.....	33.1	Red kafir.....	19.9
Dwarf Blackhull kaoliang.....	29.7	Shallu.....	11.7
Brown kaoliang.....	27.9		

The sorghum midge did not appear this season until somewhat later than in previous years, so with the earlier maturing varieties,

¹ The variety test here reported is additional to an extensive series of experiments with cotton conducted by the Office of Acclimatization and Adaptation of Crop Plants and Cotton-Breeding Investigations, the results of which will be reported elsewhere.

² U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 237, entitled "Grain-sorghum production in the San Antonio region of Texas."

such as milo, plantings made as late as April 1 gave heavier yields than earlier plantings. This was due largely to the fact that there was a poor stand in the earlier plantings.

GRAIN-SORGHUM YIELDS COMPARED WITH CORN.

Two varieties of grain sorghum, Dwarf milo and Sudan durra, were grown in comparison with 42 of the most common types of Texas corn. Sudan durra gave a yield of 57 bushels per acre and Dwarf milo 63 bushels per acre, while the best strain of corn gave a yield of 40 bushels per acre, with an average of about 30 bushels for the field.



FIG. 7.—Dwarf broom corn on the San Antonio Experiment Farm. An average yield of 657 pounds of brush per acre was obtained from plantings made on three different dates in 1912. (Photographed June 15, 1912.)

DISTRIBUTION OF SORGHUM SEED.

More than 150 requests for grain-sorghum seed were received from near-by farmers, and 209 packages were sent out to 103 of these. The varieties distributed were Dwarf milo, Sudan durra, and Dwarf Blackhull kafir. Much interest is being shown by the farmers in western Texas in the production of this grain crop, since the corn yields have been low during the past four years.

BROOM CORN.

In connection with grain-sorghum tests, three varieties of broom corn were planted, Dwarf broom corn (fig. 7) being planted on three

different dates and the others on two. The average yields from these plantings were as follows:

Dwarf broom corn, G. I. No. 442-----	657 pounds per acre.
Broom corn, G. I. No. 243-5-4-----	640 pounds per acre.
Standard broom corn, G. I. No. 446-----	730 pounds per acre.

The brush was of fair quality.

PUBLICATIONS.

As rapidly as results of a conclusive nature are secured from the experiments at the farm they are prepared for publication. In this way the facts brought out in the experimental work are promptly made available to the farmers of the region. During the year 1912 three publications dealing in detail with some of the problems under investigation were prepared. The first of these¹ treats of the production of grain sorghum, the most important grain crop of the region; the second² reports the results of five years' experimentation with forage crops, and the third³ deals with the effects produced on crop yields and soil moisture by the practice of subsoiling. Similar papers dealing with other problems will be issued from time to time as the experimental results warrant publication.

¹ U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 237, "Grain-sorghum production in the San Antonio region of Texas," by Carleton R. Ball and Stephen H. Hastings.

² U. S. Department of Agriculture, Bureau of Plant Industry, Circular 106, "Report of the forage-crop work at the San Antonio Experiment Farm," by S. H. Hastings.

³ U. S. Department of Agriculture, Bureau of Plant Industry, Circular 114, article entitled "Experiments in subsoiling at San Antonio," by S. H. Hastings and C. R. Letteer.

INHERITANCE OF WAXY ENDOSPERM IN HYBRIDS WITH SWEET CORN.¹

By G. N. COLLINS, *Botanist*, and J. H. KEMPTON, *Assistant, Office of Acclimatization and Adaptation of Crop Plants and Cotton-Breeding Investigations.*

INTRODUCTION.

As soon as European settlers in America became familiar with the different varieties of maize, the obvious classification of varieties based on the character of the seeds came into use. In very early literature we find such terms as flint, dent, and sweet referred to as representing classes already well known. The popular classification was crystallized into formal descriptions by Salisbury in 1849, but it was not until 1884, when Sturtevant extended the classification and applied as technical names Latin equivalents of the popular names, that the classification was generally recognized by scientific writers.

With the exception of pod corn, which is known only as a curiosity, these groups are all distinguished by the texture or composition of the endosperm. The discovery in China of a type of maize with a new form of endosperm added another member to this long-established series.²

BEHAVIOR OF THE HYBRIDS.

The waxy endosperm, characteristic of this Chinese variety, has never been observed in any American variety, while in all of the importations of this Chinese variety nothing but waxy seeds have been observed. When crossed with varieties that have a horny endosperm the waxy endosperm is completely recessive, the immediate result of the cross being seeds that are indistinguishable from those of horny varieties. In the second generation of crosses segregation appears to be complete, and the proportion of waxy to horny seed approximates the Mendelian monohybrid ratio, 1:3, with small, though significant, deviations. Detailed results of a series of crosses between waxy and horny are given in another place.³

In a general way waxy endosperm may be said to behave like sweet endosperm, which has also been found to be recessive to horny

¹ Issued Apr. 5, 1913.

² Collins, G. N. A new type of Indian corn from China. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 161, 1909.

³ Collins, G. N., and Kempton, J. H. Inheritance of waxy endosperm in hybrids of Chinese maize. IV^e Conférence Internationale de Génétique, Paris, 1911, p. 347-357, 1913.

versely, that what is lacking in the waxy is supplied by a sweet variety. While the horny seeds resulting from the cross between sweet and waxy were indistinguishable from ordinary horny seeds, it was, of course, to be expected that differences would appear in the progeny.

Four of the six ears obtained as a result of the crosses made in 1911 were selected for planting in 1912. The ancestry of these ears is as follows:

Dh221. White Chinese (waxy) $\times$ Voorhees Red (sweet).

Dh209. White Chinese (waxy) $\times$ Black Mexican (sweet).

Dh216. White Chinese (waxy) $\times$ Black Mexican (sweet).

Dh207. White Chinese (waxy) $\times$ Black Mexican (sweet).

The same individual plant was not used as the parent of more than one cross.

From these 4 ears 55 ears were produced in 1912. Every ear bore seeds of all three classes—horny, sweet, and waxy. The entire 55 ears had 22,132 seeds, of which 57.4 per cent were horny, 24.8 per cent sweet, and 17.8 per cent waxy. These proportions approximate the 9:4:3 Mendelian ratio involving two factors.

Since in the first generation sweet combined with waxy produced horny, it has been assumed that something necessary to produce horny is lacking in both the sweet and the waxy, and an attempt has been made to analyze the behavior of these hybrids with this idea in view. The residual factor which when it occurs alone is assumed to cause the sweet character will be called S , while X will be used to indicate the factor of the waxy character. Small letters, s and x , are used to denote the absence of these factors. Since in both sweet and waxy the alternative factor necessary to produce horny is assumed to be lacking, the gametes produced by sweet varieties will be represented by Sx and the gametes produced by varieties with waxy endosperm by sX . The synthetic horny will then be represented by a combination of these, or $SsXx$. Assuming a chance recombination of these factors in the gametes derived from these synthetic horny seeds, the gametes will be of four kinds. Both the sweet and the waxy may be present (SX), or the sweet may be present without the waxy (Sx), or the waxy without the sweet (sX), or both may be absent (sx). At fertilization each of these kinds of gametes may unite with any one of the four corresponding kinds derived from the other parent, producing 16 zygotic combinations. The formation of these combinations is represented in the conventional diagram, figure 1. The four classes of gametes from one parent are given in the horizontal row at the top, and the same four classes from the other parent in the vertical row at the left. Each gametic combination from the top is repeated four times in the squares below, while

each combination at the side occurs four times in the corresponding horizontal row of squares. Thus each of the squares represents the result obtained by combining the gametes representing the horizontal and vertical rows that intersect at that point. In all cases where both *S* and *X* occur together the seed should be horny, where only *S* occurs the seed should be sweet, when only *X* occurs it should be waxy, and in one square (No. 16), where neither *S* nor *X* occurs, no prediction can be made, since this is presumably a new condition.

Leaving the nature of the seed from square 16 out of consideration for the present, it can be seen that there are 9 squares in which both *S* and *X* occur (horny), 3 in which *X* alone occurs (waxy), and 3 in which *S* alone occurs (sweet). With respect to the horny and waxy seeds, these numbers approximate the ratios that were actually obtained, there being roughly 9 horny seeds to 3 waxy, but the sweet seeds occur as 4 instead of 3 out of every 16. We must therefore assume that the new type, *saxx*, represented in square 16 and containing neither the sweet nor the waxy factor is or resembles sweet. Careful scrutiny of the sweet seeds failed to show any consistent differences that would allow another class to be separated, but if the present method of looking at the cross is to be of use it should be possible to detect the differences between the ordinary sweet seeds and this new class by analytical breeding.

One way to test the theory that this new class of apparently sweet seeds really lacks the element ordinarily concerned in the production of the sweet character is to cross it with pure waxy. The cross of sweet and waxy has heretofore always produced horny, but if this new class lacks the factor for sweet, the cross should have the gametic composition represented by squares 12 and 15 and should result in waxy instead of horny seeds. Another test could be applied by crossing the new class with ordinary horny varieties. The first generation of this cross should be horny, but the formula of gametic composition, *SXsa*, would be the same as for the synthetic horny, and in the second generation 3 out of every 16 seeds should be waxy.

Thus, if the present assumption regarding the nature of this class is correct we may expect two apparent anomalies, not observed hitherto, viz, waxy seeds as the immediate result of crossing sweet and waxy, and waxy seeds in the second generation of a cross between sweet and horny.

COMPARATIVE WEIGHT OF HORNY, SWEET, AND WAXY SEEDS.

The view that waxy as well as sweet endosperm may be compared to incomplete stages in the production of the horny endosperm is strengthened by the relative weights of the sweet, waxy, and horny seeds where all three classes occur on the same ear. The horny seeds

are the heaviest, followed by the waxy and sweet. A total of 3,161 horny seeds weighed 790.3 grams, 2,387 waxy seeds weighed 565 grams, and 5,247 sweet seeds weighed 1,028.3 grams. Reduced to weight per seed, these results give 0.253 gram for the horny, 0.237 gram for the waxy, and 0.196 gram for the sweet. The average weight of the four classes, white horny, white waxy, white sweet, and colored sweet, was determined on 49 ears belonging to four families.¹ The results are shown in Table I. Since the average weight of seed differs on different ears, the comparative weights of the different classes are expressed in terms of the weight of the horny seeds.

TABLE I.—Weight of white waxy, colored sweet, and white sweet seeds of maize.

Family.	Number of ears.	White horny.	White waxy.	Colored sweet.	White sweet.
Dh221.....	12	100	93.8±1.02	77.7±1.52	77.4±1.40
Dh209.....	13	100	95.6±.77	76.2±1.71	76.4±1.45
Dh216.....	15	100	96.5±.95	79.3±.94	77.8±1.28
Dh207.....	9	100	94.2±.93	76.8±1.20	72.4±1.90
Total.....	49	100	95.2±.45	77.6±.65	76.4±.71

There appears to be no real difference in weight between the white and colored sweet seeds. The sweet seeds are, however, consistently lighter than the waxy, which in turn are lighter than the horny. The average difference between the sweet and waxy seeds is 22.5 per cent of the weight of the sweet; that between the waxy and horny is 5 per cent of the waxy. The volume and specific gravity of the classes of seeds were also determined in eight of the ears. The results showed that the differences in weight were associated with corresponding differences in volume, the specific gravity being the same for all classes.

COMPARISON OF RESULTS WITH MENDELIAN EXPECTATION.

In the previous pages the classes occurring in the second generation of the sweet × waxy cross have been referred to as approximating a 9:4:3 ratio. While this approximation is so close as to exclude the possibility of finding any other ratio that will more closely fit the observed number, the deviations are too large to be ascribed to chance.

Table II gives the number of horny, sweet, and waxy seeds compared with the number expected in accordance with the above ratio. For both the horny and waxy it will be seen that the deviation for the entire series is more than five times the probable error. In the case of the sweet seeds the total deviation is no greater than should

¹ The two classes, colored horny and colored waxy, could not be weighed accurately, since these seeds had been clipped in order to determine whether they were horny or waxy.

be expected, but an examination of the separate families indicates that this agreement is accidental, for of the four families one is above the expected number by nearly five times the probable error and two are below by more than three times the probable error.

TABLE II.—*Proportion of sweet, waxy, and horny seeds of maize compared with the expected ratios.*

Descriptive data.	Family.				Total.
	Dh221.	Dh209.	Dh216.	Dh207.	
Number of ears.....	12	14	17	12	55
Number of seeds.....	6,033	5,769	6,413	3,917	22,132
Sweet seeds:					
Number.....	1,399	1,358	1,720	986	5,463
Expected number.....	1,508±22.7	1,442±23.2	1,603±25.4	979±18.3	5,533±43.4
Deviation.....	-109	-84	+117	+7	-70
Deviation divided by probable error.....	4.8	3.8	4.6	.04	1.6
Per cent.....	23.2	23.5	26.8	25.1	24.7
Waxy seeds:					
Number.....	1,085	1,059	1,132	665	3,941
Expected number.....	1,131±20.4	1,082±20.0	1,202±21.1	734±11.5	4,149±39.1
Deviation.....	-46	-23	-70	-69	-208
Deviation divided by probable error.....	2.3	1.1	3.3	6.0	5.3
Per cent.....	18.0	18.4	17.7	17.0	17.8
Horny seeds:					
Number.....	3,549	3,352	3,561	2,266	12,728
Expected number.....	3,394±25.9	3,245±25.3	3,608±26.8	2,204±20.9	12,450±49.6
Deviation.....	+155	+107	-47	+62	+278
Deviation divided by probable error.....	6.0	4.2	1.8	3.0	5.6
Per cent.....	58.8	58.1	55.6	57.8	57.5

CONCLUSIONS.

The general classification of maize varieties is based on the characters of the seed. Varieties with horny, soft, and sweet endosperm have been recognized since early colonial times, and these three types represent the only forms in which the endosperm of maize was known to exist until the discovery of waxy endosperm in a variety of maize introduced from China in 1908. Investigations of the heredity of this new type of endosperm show that when the Chinese variety is crossed with sweet varieties seeds are produced which, unlike either parent, have a horny endosperm. Although this synthetic horny endosperm is indistinguishable from that of ordinary field varieties, it behaves in an entirely different manner in the following generation.

All of the plants grown from these hybrid seeds produced ears with horny, sweet, and waxy seeds. The proportion in which the three classes occurred approximated nine horny, four sweet, and three waxy, a ratio indicating that the sweet and waxy characters are the result of independent factors and that one out of every four sweet seeds, though indistinguishable from ordinary sweet seeds in the first generation, represents a new type of sweet corn. Experi-

ments have been outlined for isolating and determining the nature of this new type.

Since all three classes of seeds occurred on the same self-pollinated ear, it was possible to compare the weights of the three classes where the parentage of all was identical. The horny, waxy, and sweet seeds from each of 49 ears were separately weighed. The result showed that in nearly every ear the horny seeds were heavier than the waxy, which were in turn heavier than the sweet. Specific-gravity determinations of the different classes showed no significant differences. The differences in weight must therefore be due to differences in size.

[Cir. 120]

LEAF-CUT, OR TOMOSIS, A DISORDER OF COTTON SEEDLINGS.¹

By O. F. Cook, *Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.*

INTRODUCTION.

Seedlings and young cotton plants are subject to a peculiar disorder that results in extensive injury to the leaves and frequent abortion of the terminal bud. While these injuries are seldom fatal, they undoubtedly impede the growth of the plants, delay the period of production, and reduce the crop. Though not taken into account hitherto, the losses occasioned by the leaf-cut disorder, though most severe in the Southwestern States, seem to be very general and must amount to millions of dollars every year. With the advance of the boll weevil this form of injury to the young plants acquires a more serious aspect, because it is of the utmost importance to shorten the period of production in order to avoid damage by the weevil. The leaf-cut handicap can be reduced by improved cultural methods, as stated in previous publications of the Bureau of Plant Industry.²

LEAF-CUT DISTINGUISHED FROM LEAF-CURL.

Leaf-cut is suggested as a popular name because mutilations of the leaves are the most characteristic symptom of the disorder. The name "juvenile leaf-curl" has been applied in previous publications, but is inconveniently long and not sufficiently distinctive. Moreover, the leaves of cotton seedlings are subject to another malformation, induced by plant lice, for which the name "leaf-curl" is more appropriate.

Leaf-cut is very widely distributed and familiar to planters, though generally confused with the leaf-curl caused by plant lice. Though both forms of injury are likely to be found in the same field, or even on the same individual plant, they are easily distinguished. (Fig. 1.) The leaf-curl is a crumpling or arching up of the leaf between the veins, but without perforations or rents. Even in cases of great distortion by leaf-curl the tissues of the leaf are left entire, without

¹ Issued Apr. 5, 1913.

² See Report of the Chief of the Bureau of Plant Industry, U. S. Department of Agriculture, for 1911, p. 24; for 1912, p. 27; and U. S. Department of Agriculture, Bureau of Plant Industry, Circular 96, p. 13.

being punctured or torn. Leaf-cut injuries, on the other hand, represent an actual destruction of some of the tissues of the leaf, leaving irregular holes or marginal incisions. In single words, leaf-curl may be described as distortion of the leaves, leaf-cut as mutilation. In allusion to this distinction the word "tomosis" is proposed as a technical name for the leaf-cut disorder, while the distortion caused



FIG. 1.—Young plant of Egyptian cotton grown at Lanham, Md. The lower leaves are affected by leaf-cut and upper leaves by leaf-curl. (Natural size.)

by the plant lice may be called "hybosis." The insects inhabiting the badly distorted upper leaves of figure 1 were identified by Mr. Th. Pergande, of the Bureau of Entomology, as *Aphis gossypii* Glover.

And in addition to the open wounds that result from leaf-cut there are usually some that have healed, giving a characteristic torn-and-mended appearance. Such scars, like other leaf-cut wounds, often

lie in a somewhat radiating position between the principal veins. Healing of wounds and regeneration of lost parts show that the injuries are liable to occur at a very early stage in the development of the leaf. Sometimes an extensive new growth or regeneration takes place, resulting in a curious doubling or overlapping of lobes of injured leaves. The power of the injured tissues to heal is also responsible for adhesions between parts that lie folded together in the bud. These adhesions are usually responsible for failure of normal expansion of the blade. None of these secondary symptoms occur with the leaf-curl induced by plant lice.

CAUSES OF LEAF-CUT INJURIES.

Leaf-cut is hardly to be reckoned as a disease unless the word is used in its most general application that includes any departure from normal structure or function. Neither of the two general classes into which diseases are usually divided, constitutional and parasitic, would include the leaf-cut. Though some of the cells are destroyed, the remaining tissues of the plant do not become abnormal in any way, and there is no indication that parasitic organisms of any kind—bacteria, fungi, insects, mites, or worms—are involved. Another class of ecological disorders may need to be recognized, intermediate between physiological diseases and mechanical injuries or traumatism. Leaf-cut is a disease only in the sense that frostbite, snow blindness, and other environmental injuries are to be considered as diseases.

Young cotton plants are often subjected to extreme conditions during the early stages of growth, when the leaf-cut injuries occur. The leaves and roots are still close to the surface soil, where they can be chilled at night and scorched in the daytime. Cold nights are sometimes looked upon as the cause of the injury, and may be an intensifying factor, but the sudden heat of a bright morning sun seems more likely to kill the cells of the young leaves than low temperatures during the night. Leaf-cut often affects late plantings long after the night temperatures have ceased to approach the freezing point. It has been noticed that exposure to a bright morning sun after a cold night will throw cotton seedlings temporarily into a wilted state, doubtless because the leaves lose water by transpiration faster than it can be absorbed by the chilled roots. Leaf-cut seems to be especially prevalent under such conditions.

That leaf-cut is in some way connected with exposure or wilting of the delicate tissues is also shown by the fact that the injuries are most severe and occur most frequently along radiating lines midway between the principal veins. These lines of greater susceptibility represent the most exposed parts of the upper surface of the young

leaf as it lies folded in the bud. The only suggestion for explaining the very irregular manner in which the cells are killed is that some of them may be unable to complete their divisions and nuclear readjustments during the night and may thus be left in an unusually susceptible condition. Sections of injured leaves prepared by Dr. Albert Mann, of the Bureau of Plant Industry, show that nuclear and protoplasmic disintegration are the earliest symptoms. The damage often begins with the death of a single cell, which results, of course, in increased exposure for the neighboring cells.

Plants protected by partial shade suffer less than those that are fully exposed, but, on the other hand, full exposure does not induce leaf-cut when the plants are growing on wet land, where the surface remains moist and is kept cool by evaporation. The moist atmosphere and partial shade afforded by ordinary greenhouse conditions also afford complete protection from leaf-cut.

Even in parts of the same field there may be obvious differences in the extent of leaf-cut injury. Plants that stand close together often show much less injury than more scattering plants in the same rows. Where the soil is too dry to germinate all the seed the leaf-cut injuries are more extensive. Such differences indicate the possibility of avoiding or reducing the damage from leaf-cut by giving better attention to the seed bed and to methods and times of planting and thinning.

ABORTION OF TERMINAL AND AXILLARY BUDS.

Though mutilation of the leaves is the most frequent and familiar symptom of the leaf-cut disorder, abortion of terminal buds is a more serious injury. In severe cases of leaf-cut, from 30 to 60 per cent of the plants have been found with their terminal buds aborted. When the leaf-cut injuries are confined to the individual leaves the effect is merely to retard the growth of the plant, but when the terminal bud is lost the plants are permanently deformed and usually produce a much smaller and later crop than normal individuals in the same field.

In the most severe form of the disorder the young seedlings lose the buds in the axils of the cotyledons as well as the terminal bud. Such plants are unable to form any true leaves, but the cotyledons increase in size and the hypocotyl becomes much thickened. In some cases the root begins to form a subterranean shoot, like those that develop vegetative buds when plants have been killed to the ground in the winter. When abortion of the bud takes place higher up, so that the plants have one or two true leaves, the blades grow much larger than usual and the petioles become greatly elongated. If thinning be deferred until the normal plants are 10 inches or a foot

high it is easy to distinguish and remove the deformed individuals and leave only the healthy and vigorous ones. Under the usual plan of thinning the cotton early it is much more difficult to recognize and remove the injured plants.

SUSCEPTIBILITY AND IMMUNITY.

Susceptibility to leaf-cut is usually limited to the seedlings and young plants less than 10 inches high. Sometimes the change from susceptibility to immunity is very abrupt. Plants that have had every leaf injured up to the sixth or eighth may then begin to put out entirely uninjured leaves. These abrupt changes may affect whole rows or fields of cotton, as if the later uninjured vegetation had grown out after a hailstorm. Whether the plants become immune to leaf-cut simply because larger stature carries the new growth farther away from the overheated soil, or because a deeper root system affords a more regular supply of moisture, or because the weather conditions become more uniform as the season advances has not been determined. All these factors may cooperate, or there may be others as yet unsuspected.

A few cases of abnormal individuals have been observed where injuries very similar to leaf-cut continued during the whole life of the plant. Some of these plants were hybrids and others were mutations, but all of them were abnormal in other ways, as well as in the irregular texture of the foliage. It seems not unreasonable to suppose that abnormal plants should remain more susceptible to any external conditions that have adverse effects upon the activities of the cells.

Though all the different types and varieties of cotton seem to be susceptible to leaf-cut injuries, certain differences have been noticed. The leaves of the Durango cotton and other Upland varieties are often injured much more seriously than those of Egyptian cotton in adjacent rows, but at the same time the Egyptian cotton may show a larger percentage of abortion of terminal and axillary buds. The immunity may lie in the improvement of conditions rather than in an increased resistance on the part of the plant. With the plant-lice injuries there is a gradual reduction of the amount of distortion that the insects are able to produce, which may indicate the development of a different kind of immunity in this disorder. It is true that the plant lice usually disappear as the season advances, but even when the insects remain abundant the distortion becomes less as the plants grow larger.

CONCLUSIONS.

Leaf-cut is a disorder of cotton seedlings characterized by mutilation of the leaves and abortion of the terminal buds. Leaf-cut has

been confused with the distortion of the leaves by plant lice, but the two malformations are readily distinguished.

Leaf-cut is in the nature of an environmental injury, not due to parasitic organisms or to constitutional weakness, but apparently connected with exposure to heat and dryness. All varieties of cotton are susceptible during the early stages of growth.

Though leaf-cut is not fatal, it is responsible for much damage by retarding the growth of the young plants. The loss of the terminal buds interferes with normal habits of branching, and the plants are permanently deformed. Damage from leaf-cut can be avoided or reduced by improved cultural methods, and the deformed plants can be removed by later thinning.

[Cir. 120]

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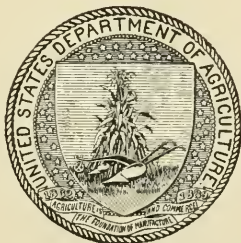
BUREAU OF PLANT INDUSTRY—Circular No. 121.

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

The Culture of Durango Cotton in the Imperial Valley	ARGYLE McLACHLAN
The Control of the Sugar-Beet Leaf-Spot	{ V. W. POOL and M. B. McKAY
The Work of the Huntley Experiment Farm in 1912	DAN HANSEN
Methods of Securing Self-Pollination in Cotton	R. M. MEADE

Issued April 12, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, WILLIAM A. TAYLOR.
Assistant Chief of Bureau, L. C. CORBETT.
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[Cir. 121]

THE CULTURE OF DURANGO COTTON IN THE IMPERIAL VALLEY.¹

By ARGYLE McLACHLAN, *Assistant in Crop Acclimatization, Office of Western Irrigation Agriculture.*

INTRODUCTION.

Durango cotton is a long-staple Upland variety recently introduced by the United States Department of Agriculture and apparently well adapted to Imperial Valley conditions. A general account of the variety and of its behavior in the Imperial Valley in comparison with other long-staple sorts has been given in a recent publication.² The object of the present paper is to call attention to special methods and precautions that need to be observed in the development of a long-staple industry under the local conditions. Most of the planters have grown only short-staple cotton in the past and many are not familiar with cotton culture or with methods of irrigation.

Durango cotton was first grown in the Imperial Valley in 1911 by Mr. W. E. Wilsie on 3 acres of land near El Centro. In 1912 about 200 acres were planted by six growers from seed grown by Mr. Wilsie. Following the favorable results obtained in 1911 and 1912, it appears that between 6,000 and 7,000 acres will be planted to Durango cotton in the Imperial Valley in 1913. All the available supplies of Durango seed in Texas were purchased. A much larger acreage would be planted if more seed could be obtained. It is also estimated that about 20,000 acres more will be planted to short-staple cotton, chiefly of the Mebane (or Triumph) variety. This total estimate of 26,000 or more acres includes acreages to be planted in Lower California adjoining the Imperial Valley, which are operated chiefly by residents of the valley and from which the crops are marketed through Imperial Valley points.

In undertaking the growing of this greatly increased acreage of Durango long-staple cotton, it should be appreciated at once that better care of seed and more care in cultivation, harvesting, ginning, and handling are required in producing cotton with long and uniform lint than merely for producing short-staple cottons.

¹ Issued Apr. 12, 1913.

² Cook, O. F. Durango cotton in the Imperial Valley. In U. S. Department of Agriculture, Bureau of Plant Industry, Circular 111, 1913.

The most essential step in connection with a long-staple cotton industry is the establishment and maintenance of clean and select seed of the variety. Deterioration of a variety from failure to select the seed or through carelessness in keeping it free from mixture with seed of other varieties can not be overcome by cultural or other methods. The cotton industry of the Imperial Valley will be best served if proper means are taken during the season of 1913 to insure a supply of select, pure Durango seed for planting in 1914.

CLEAN SEED FOR PLANTING IN 1914.

MIXED SEED SHOULD BE DISCARDED.

The great promise of the Durango variety has led the cotton growers to plant this year all available seed, though it is known that a large proportion of it is mixed or impure and can be used only for a single season.

At least three-fourths (or about 4,500 acres) of the Durango cotton acreage in the Imperial Valley in 1913 will be planted to seed which was grown in the valley in 1912. Unfortunately, this seed has been mixed and cross-pollinated with short-staple cotton. The seed planted in 1912 was grown in the valley in 1911 on clean land which had been in alfalfa the preceding season, so that no mixture occurred in the field. A small amount of mixture (possibly 2 to 4 per cent) occurred in the ginning of the Durango seed in 1911. The mixing probably took place in the screw conveyor which carries the seed from the gin stands to the wagon.

The most serious mixture occurred in the fields in 1912. A large part of the Durango cotton was planted on land which had been in short-staple cotton in 1911, and the volunteering of the previous season's variety caused an actual mixture of short-staple plants in the Durango fields amounting to 8 to 20 per cent. This has resulted not only in an actual seed mixture in the crop produced in 1912, but also, and what is even more serious, in the hybridization of the Durango with short-staple cotton. Either sort of mixture, if allowed to persist, would prove disastrous to the new long-staple industry. Seed mixture alone in stocks of valley seed might be successfully overcome, but the cross-pollination of the Durango by short-staple varieties is a mixture practically impossible to eradicate. While some of the valley Durango seed to be planted in 1913 contains not more than 5 per cent of short-staple seed, the hybridization which has taken place makes it essential for the eventual good of cotton growing in the Imperial Valley that all mixed seed be sent to the oil mill or some other seed-destroying agency this fall, so that no stock of mixed Durango seed can be planted in 1914.

Fortunately, a small quantity of uncontaminated Durango seed (enough to plant about 700 acres) has been secured from Texas for 1913 planting, and a small quantity was grown in the Imperial Valley under conditions that warrant its purity. If handled properly in 1913, the crop from this seed will yield an abundance of clean seed for all local needs in 1914.

RESPONSIBILITY OF PLANTERS OF CLEAN SEED.

Those who plant clean seed in 1913 should assume the responsibility of providing clean seed for planting in 1914. The practical bearing of this responsibility of the individual planter is in the fact that the establishment of a long-staple industry depends largely on the production of large quantities of first-class Durango cotton. The production of 10,000 or 20,000 bales of such cotton in 1914 and succeeding years would mean much to the Imperial Valley. The man who, through carelessness in 1913, allows clean seed planted on 50 or 100 acres to become mixed may cut down the production of first-class Durango cotton in 1914 to the extent of 2,500 to 5,000 bales. It is therefore important that each grower take it upon himself to keep his clean Durango seed from becoming mixed with other varieties.

PRESERVATION OF CLEAN SEED.

CLEAN LAND.

In the first place, all clean seed should be planted on clean land. If planted on land cropped to cotton in 1912 there is every probability that mixture will be occasioned by the volunteering of seed scattered from the previous crop. Up to the present there has arisen no necessity for the eradication of volunteer cotton, so that methods to this end have not yet been devised. The condition of cleanness of fields on which to plant pure Durango seed should be absolute in order to insure the desired end of raising clean Durango seed. A few volunteer plants of another variety in the field, along borders, or in fence corners are as dangerous as a great number.

ISOLATION.

Further, plantings of clean Durango seed should be made in fields isolated from plantings of other varieties of cotton, in order to guard against cross-pollination of the Durango by insects. If it proves impracticable to isolate the field of clean Durango by distance (of one-eighth mile or more), the precaution should be taken to plant a wide strip (50 feet or more) of milo or of some other tall-growing crop between the Durango and other cottons.

MINOR DETAILS.

It would seem unnecessary to call attention to the danger of mixing Durango seed with other varieties at planting time, but acquaintance with carelessness in the small details of cotton handling makes it apparent that warning should be sounded against the possibility of mixing in each operation connected with the planting and growing of the crop. This is important in cases where the Durango and Mebane cotton are planted on the same farm. Sacks containing Durango seed should be marked "Durango." The handling of the seed should not be intrusted to incompetent hired help, who might not appreciate the importance of such details. The planting machine should be thoroughly cleaned of any seed which may have become lodged while planting seed of another variety.

PROPER TILTH.

Instances have occurred in the planting of cotton in the Imperial Valley where replanting has been necessary because of poor tilth. It would be a serious loss to the industry if any of the clean seed were to fail to yield a good stand through lack of thorough and special preparation of the land. There is a very limited supply of clean Durango seed and none with which to replant.

CLEAN CONVEYANCES.

Special care to prevent mixing must be exercised at picking time as long as other varieties of cotton are being harvested in proximity to the Durango or even in the same valley. Wagon racks in which other cottons have been hauled should be cleaned of stray bits of seed cotton before loading Durango cotton. Cars in which Durango seed cotton may be transported to the gins should likewise be properly cleaned. The identity (number and name) of the car in which the clean Durango seed cotton is carried should be clear to grower and ginner alike immediately on shipment. The producer should accompany his clean Durango seed crop to the gin and assist the ginner in seeing that the conveyors to the gin stands, the feeders, and the cleaners are thoroughly cleaned of other cotton seed previous to ginning the Durango. The aprons of the gin stands should be removed and the seed sacked from the floor in front of the stands instead of being caught in wagons after passing through the screw conveyor beneath the stands. One can not honestly claim that his seed is salable for planting purposes unless he takes every precaution to preserve its purity.

HANDLING PLANTINGS OF MIXED SEED.

A certain responsibility to the cotton industry of the Imperial Valley rests on those who plant mixed Durango seed. Their immediate responsibility consists in doing their utmost to provide first-

class Durango fiber from their mixed crop in order to increase the outturn of high quality cotton from the valley. This can best be accomplished by removing the short-staple plants from the mixed Durango field previous to picking time.

The eradication of the Mebane plants and plants of other varieties of cotton from plantings of mixed Durango is entirely feasible, as Durango plants display characteristics of leaf and other features which distinguish them throughout their growth from plants of other varieties. Durango leaves have narrower and more sharply pointed lobes than Mebane leaves, and appear more definitely five lobed. Growers should take the first opportunity presented to compare Durango and Mebane cotton plants in order to become acquainted with these differences. It will be possible to distinguish and cut out many of the plants of other varieties at chopping time. By persistent effort all short-staple plants can be eradicated from the mixed Durango fields. This will leave in the fields only Durango and some hybrid plants which will yield much higher quality fiber than fields from which the short-staple plants have not been removed. There is no reason why fields of mixed Durango, if handled in this manner, should not yield fiber this season of as good character as that from fields of clean Durango.

PAST EXPERIENCE GUARANTEES PROGRESS.

A distinct advance has been made by the cotton-growing community of the Imperial Valley since the planting of "Georgia" cotton in 1909. The advance thus far accomplished amounts to the establishment within a period of four years of a short-staple industry based practically on the best obtainable variety of short-staple cotton. The experience already gained through the eliminating from the industry in the Imperial Valley of numerous varieties of cotton which have been tested and proved poorly adapted to the conditions should make it possible for the cotton growers to take the necessary steps in connection with a long-staple industry for maintaining clean stocks of seed of one accepted variety and of providing proper culture to produce superior fiber.

PROPER CULTURE TO PRODUCE GOOD FIBER.

Good Durango fiber, $1\frac{3}{16}$ to $1\frac{1}{4}$ inches long, of even length and of good strength, can be grown by providing the plants with normal growing conditions through the season. Water should be applied in such a way as to allow the plants to grow and fruit normally without being subjected either to drought or overwatering or to undue checking or acceleration of growth. Either checking or accelerating growth has a direct effect in causing diversity in the length and

strength of fiber. Irregularity of any sort is of much more serious consequence in the case of long-staple than in short-staple cottons.¹

Water should be given the plants as they require it rather than at stated intervals. The grower should be able to tell by the appearance of the plants when they need water. Slight wilting at midday during very hot weather is not an indication that the plants are suffering for water if they freshen up in the evening and morning. It should be kept in mind by all cotton growers that overwatering may cause damage from which the plants will be unable to recover because of the destruction of the tip buds of the stem and branches which continue the growth.

Land containing a quantity of humus, such as lands which were heavily covered with brush previous to reclamation or old alfalfa sod lands, will produce Durango cotton of better character than lands which are poor in humus or which have been previously overcropped. The cotton industry of the Imperial Valley would profit greatly if all Durango cotton this season could be planted on alfalfa sod land. Not only would this guarantee a larger crop and more clean seed for use in 1914, but better and more valuable fiber.

It can be foreseen that not all who plant Durango cotton this season will produce a satisfactory crop. The best grown Durango, which will yield over a bale per acre of excellent fiber, must be used as a basis for judging the crop value of Durango cotton. It must not be lost sight of that the failure to plant on good land or the failure to water in a way to provide normal growth is conducive in the case of long-staple cotton not only to shortage of the crop, but to unevenness and shortness of the fiber.

PREPARATION OF LAND.

Success has been attained by following widely different methods of planting, cultivation, and irrigation of cotton in the Imperial Valley. This is largely due to the great variations in soil and partly, no doubt, to the fact that water for irrigation has been practically unlimited as yet. It has been possible to apply sufficient water to grow a crop of cotton without conserving the moisture by cultivation.

The growing of Upland cotton under irrigation is at best still in the experimental stage. It is highly probable that methods of cotton culture in the Imperial Valley may be materially changed during the next few years. Changes which will bring about the production of a uniform quality of cotton will be of great value to the industry. The following cultural suggestions may serve to promote proper adjustments in the methods of cotton culture under irrigation.

¹ Cook, O. F. Cotton improvement under weevil conditions. U. S. Department of Agriculture, Farmers' Bulletin 501, p. 14-15.

Cook, O. F. Results of cotton experiments in 1911. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 96, p. 6-7.

PLOWING.

Irrigated lands should be thoroughly and deeply stirred in preparation for planting cotton in order to insure necessary aeration and to put them into condition for the storage of water and the proper growth of the plants. Some "soft" lands containing an abundance of humus may not require more than a thorough disking before being planted for the first time, but after a season of settling and packing by irrigation all characters of soil will be benefited by thorough plowing.

DISKING AND HARROWING.

Following heavy irrigation, soft lands can be put into condition to plant flat by disking and harrowing. This saves the labor of listing. The seed is planted in the moist soil and germinated without irrigation after planting. It is much more difficult to handle heavy soils in this way. Usually following irrigation the heavy soil is listed and the seed is planted on the ridge and germinated by running water through the furrows.

FURTHER PREPARATORY OPERATIONS.

Land that is to be planted flat should be mulched by harrowing, to conserve the moisture and keep the land soft until planting time. On land that has been listed the ridges should be pulled down by cross-harrowing, to leave the tops flat and broad and with the soil on top well pulverized. It should be kept in mind that all the operations of land preparation are for the purpose of securing full and prompt germination by providing the seed with proper conditions of soil and moisture.

PLANTING.

PLANTING TIME.

As a general rule the best results will be had from planting after March 20. Earlier plantings may be subjected to numerous setbacks, amounting in some instances to a complete loss of the stand. All cotton should be planted by the last of April, though good crops have been grown from May plantings.

DEPTH.

Planting is done with a 1-row or 2-row machine planter. If only a very limited quantity of choice seed is available a larger acreage can be planted by dropping the seed by hand, four or five to the hill. The seed should be covered to a depth of $1\frac{1}{2}$ to 2 inches.

DISTANCE.

It is usual to plant rows from 3 feet 6 inches to 3 feet 10 inches apart.

LATE THINNING AND CLOSE PLANTING.

Plants are usually thinned to stand 18 inches or more apart in the row when they are about 5 inches tall. Late thinning, when the plants are about 10 inches tall, to leave them 8 to 12 inches apart will in all probability provide better conditions for cultivation and harvest, as well as a larger crop.¹ Durango cotton adapts itself especially to this plan. From the results of tests of the new method of thinning it would appear that marked progress can be expected in cotton culture by the introduction in the Imperial Valley of late thinning to close distances. It is suggested that cotton growers in the valley try this new method on a few acres of their plantings.

CULTIVATION.

HARROWING YOUNG COTTON.

Crusted soil, occasioned by rains or by irrigation water covering the rows while the plants are small, should be thoroughly stirred by harrowing across the rows. This treatment is of great benefit to young plants and will usually save the stand if the seed is in process of germination.

INTERTILLAGE.

Thorough cultivation of a nature to maintain a thick mulch on the surface should be practiced following irrigation as long as the plants will permit passage between the rows. This will insure a steadier and more even supply of water to the plants and thus a more normal growth.

IRRIGATION.

IRRIGATION BY FLOODING.

Flat irrigation, which allows the water to stand against the plants, is not necessarily harmful on soft lands, where no caking of the soil can occur about the plants, unless the water is left long enough to scald. Flat irrigation on hard land has the disadvantage of causing a caking of the soil, which is especially undesirable about young plants.

INFREQUENT EARLY IRRIGATION.

Irrigation should be deferred as long as possible after the cotton is up to stand. It is undesirable to crowd the young plants by early irrigation into excessive vegetative growth, which will later have to be sustained by heavy and frequent irrigations and will result in a crop difficult to pick because of oversized plants. Other disadvantages result unless precaution is taken to control the growth of plants when young.

¹ See U. S. Department of Agriculture, Bureau of Plant Industry, Circular 115, article entitled "A new system of cotton culture," by O. F. Cook.

DETERMINING WHEN TO IRRIGATE.

The grower should watch the growing tip of the cotton plants for indications that the plants need water. While a general wilting in the hottest part of the day does not necessarily mean that the plants are suffering for water, wilting of the young leaves of the growing tip or stoppage of growth is usually a clear indication that the plants are getting too much or too little water. Long-staple cotton will be most successfully grown by those who apply water when the plants indicate that they need it in order to make uninterrupted growth.

PLANTING IN FURROWS AND VOLUNTEERING.

Planting in shallow furrows may find its place in cotton culture in the Imperial Valley in connection with the volunteering of the crop. The soil gradually worked toward the plants in the process of cultivation will cover the lower buds of the stem, so that when cultivation is completed in midsummer one to three of the buds will be completely protected. This protection should preserve the buds from killing frosts in the winter, so that prompt and uniform volunteering can be brought about in the spring by turning the soil away from the old stumps. Otherwise, volunteering is a slow and uncertain process.

CLEAN PICKING.

Cleaner picking and handling of long-staple cotton should be practiced more than has been the custom in connection with short-staple cotton. The advantage of clean grade has been appreciated in the sales of short-staple cotton during the past season. It is even of greater comparative value in the case of long-staple cotton, as low grade occasions greater comparative loss in value in long-staple than in short-staple cotton.

Cleaner picking can be insisted on. The seed cotton in the field can be dumped on big canvas wagon sheets instead of on the ground to gather more trash and grit, or into wagons standing in the field, and it can be covered at night to exclude blowing sand. Any expedient used to provide higher grade cotton is of distinct advantage to the grower.

CENTRALIZED GINNING.

If a central ginning plant is provided for ginning Durango cotton exclusively, it will be very desirable that all Durango cotton in the valley be sent there. The equipment should be suited to handling the long-fibered cotton in a way to preserve its value and to turn out high grade. Less difficulty will be found in preserving clean stocks of seed, a more uniform and superior bale can be turned out, and centralization will facilitate sale. All these items are of advantage to the grower.

SUMMARY.

Durango cotton is a long-staple Upland cotton recently placed in commercial culture in the Imperial Valley through the distribution of seed by the United States Department of Agriculture. It produces an even fiber $1\frac{3}{16}$ to $1\frac{1}{4}$ inches long, yields heavily, and turns out 31 to 32 per cent of lint. It has large bolls and can be picked about as easily as short-staple cotton.

More than 6,000 acres will be planted to Durango long-staple cotton in the Imperial Valley in 1913. About 4,500 acres will be planted to mixed valley-grown seed. The remaining acreage will be planted to Durango seed brought from Texas, some of which is known to be free from mixture with other varieties of cotton. About 20,000 acres will be planted to short-staple cotton in the same valley.

A long-staple cotton industry based on Durango cotton can be established only by maintaining clean and select stocks of Durango seed and by using the proper cultural methods to provide normal growth for the plants and fiber. A great advantage can be gained by better methods of picking and handling the mature crop.

Each individual who plants clean Durango seed this spring should assume the responsibility of providing clean seed from his crop for planting extensively throughout the valley in 1914. In order to provide such clean seed he must take every precaution until the seed is finally sacked next fall to prevent mixture with other cotton.

Planters of mixed seed by industrious attention to the removal of plants of foreign varieties from their mixed Durango fields can insure themselves a more valuable product in even fiber than if they leave the short-staple plants to be picked with the Durango. By application to the matter of distinguishing the Durango plant type from plants of other varieties in his own field the planter of mixed seed takes a step toward learning to breed superior cotton.

Cotton growers should compare Durango with Mebane plants at their first opportunity and distinguish for themselves the differences in the leaf and bract characteristics.

No seed from mixed Durango fields should be preserved for planting in 1914.

Durango cotton $1\frac{3}{16}$ to $1\frac{1}{4}$ inches long and of even-running length can be produced only by providing conditions of culture that will allow normal, unaccelerated, and unchecked growth of the plant. Underwatering or overwatering or any shocking of the plant growth will tend to cause unevenness and other undesirable features in the fiber.

Clean picking (to exclude trash) should be insisted upon, as it insures a clean grade, which is of decided advantage in selling.

The centralization of the ginning of all Durango cotton grown in the Imperial Valley will prove of definite advantage to grower and ginner alike.

THE CONTROL OF THE SUGAR-BEET LEAF-SPOT.¹

By V. W. POOL and M. B. MCKAY, *Scientific Assistants, Cotton and Truck Disease and Sugar-Plant Investigations.*

INTRODUCTION.

A detailed investigation of the leaf-spot of the sugar beet is at present being carried on in cooperation with the American Beet-Sugar Co., at Rocky Ford, Colo. Although the study is as yet incomplete, a brief account of the results thus far obtained and interpreted may prove helpful to those interested in sugar-beet problems.

THE CAUSE OF THE LEAF-SPOT.

The leaf-spot of the sugar beet is caused by a parasitic fungus. In its development this fungus, *Cercospora beticola* Sacc., produces fruit bodies or spores. When these spores fall upon the surface of a beet leaf, the temperature and moisture conditions being favorable, they germinate and push through the breathing pores into the interior of the leaf. After an entrance has thus been gained the fungus continues to grow, kills the adjacent leaf portions, breaks out through the dead area or "spot," and here produces more spores, which in turn cause infections at other points on the leaf surface, and thus the life cycle of the fungus is continued. The masses of spores on the diseased areas give to the leaf-spot the grayish color which is so readily recognized during July, August, and September. The spot is usually surrounded by a red ring, which represents the attempt of the beet plant to isolate the invading organism and prevent its further spread through the leaf. The individual spots do not increase to any great size, but new spots are continually being formed, and when the number reaches approximately a thousand the entire leaf is killed and the beet plant is forced to produce more leaves in order to keep normal the manufacture of the sugar in the plant. If too many leaves are killed the beet plant can only maintain its normal sugar production by temporarily reducing the amount in the root. Accordingly, sugar from the root is transferred and used in the development of new leaf tissue. Since this sometimes requires from 3 to 5 per cent of the sugar content of the root, the final total is correspondingly reduced.

¹ Issued Apr. 12, 1913.

THE OVERWINTERING OF THE ORGANISM.

During 1912 search was made to find, if possible, some plant other than the sugar beet which was harboring the leaf-spot organism, and upon which a winter stage of the fungus might occur, but no such plant was found. There is still, however, the possibility of the existence of such a host.

A detailed examination was also made of the beet balls of each variety of beet seed that the American Beet-Sugar Co. had on hand for the season of 1912 at Rocky Ford, Colo. This examination did not reveal any spores of the *Cercospora* fungus which were capable of germination. The work was carried on in a way which was positive enough to admit of the assertion that no leaf-spot occurred in this vicinity during 1912 as a result of the beet seed used. However, while *Cercospora* spores capable of germination did not appear upon the beet balls of the 1911 output, it can not be concluded that every year's output will give like results, since at present there seems to be a possibility that the disease must be carried upon the seed into localities which are entirely isolated from sugar-beet growing sections. Recent reports of *Cercospora beticola* from Europe indicate that the spread of the disease from this source is slight.

The soil as a harboring agent of the leaf-spot fungus is of importance because of the manure, beet leaves, and crowns that are to be found in it. The possibility that manure carries the leaf-spot organism over from one season to the next is very slight, if, indeed, it can be considered to be a factor of any importance in the light of recent experiments. The indications are that the organism is entirely killed by its passage through the alimentary tract of cattle, pigs, and sheep. It is at least certain that its growth is greatly inhibited. Of course, where beet-top "hay" is fed in such a manner that it is not entirely eaten up, this means of getting rid of the disease would be at fault.

It has been proved repeatedly during the last year, and thus far this year, that the leaf-spot organism remains alive upon the old beet tops, including the leaves, petioles, and crowns, which are left from the previous year's crop. It makes no difference where these tops are left; they are capable of producing infection.

FIRST APPEARANCE OF INFECTION.

Since, then, *Cercospora* is carried over from one year to the next upon the old beet tops which are left in the field and which later disintegrate in the soil, the first appearance of the leaf-spot in the following season should come on the first-formed leaves of the beet plants or those nearest the soil where the source of infection occurs. This is actually what happens. In last season's work it was found to be the rule that in fields which were known to have had leaf-spot

during the preceding year and where the tops were allowed to remain upon the ground, the first infection in the new crop appeared upon the leaves which rested upon the ground or were more or less submerged and held to the ground through irrigation. In contrast to this, a field of beets which followed alfalfa for the first time showed a period of infection about three weeks later than the preceding. Moreover, the first symptoms of the disease were upon the leaves which were well exposed to the air. This may be explained in the following way: When the new beet leaves attain sufficient size the temperature and humidity being favorable, the fungous organism in the old leaves, which lie immediately beneath the new growth, becomes active and infects the new leaves near the ground. Now, if there happens to be no material affording such source of infection, as in the case of the second field mentioned, where sugar beets followed alfalfa, infection becomes impossible except from living spores of the leaf-spot fungus carried in the air. Such infection occurs only after the spores formed upon the lowest leaves find their way into the air. They then fall upon the higher and more exposed leaves and produce infection here rather than upon the leaves near the ground, which are more or less covered. Thus, the second infection coming later and appearing on a different part of the plant points to the fact that if the first infection did not occur other infections would be impossible.

CAUSES FOR THE SPREAD OF INFECTION.

It has been proved to be a fact that the leaf spots increase only slightly in number upon the old leaves which have passed the period of their greatest activity and are beginning to yellow. Numerous spores, however, which are produced in these spots infect the surrounding green leaves, so that the source of infection is continued even after the old leaf is dead. When the condensed moisture upon the leaves dries, the spores of *Cercospora* are borne by the wind or simply float through the air to other leaves, or they may be carried from one plant to another by insects, by man, or upon various kinds of cultural implements. The irrigation water has been proved to be one way in which the organism may be carried from one place to another in the same field, or through the drainage water to other fields.

POSSIBLE CONTROL BY REMOVAL OF BEET TOPS.

Since the beet tops and crowns are the great source of infection and afford a means of carrying the disease over from one season to the next, it is evident that care should be taken to remove these from the fields as thoroughly as possible. In order to do this, the tops should

be removed while still green. Otherwise, if the material is allowed to remain upon the ground for two or three days some of it becomes extremely brittle and breaks up easily on account of the rapid drying which usually takes place. The methods of beet-top removal now in practice in the Arkansas Valley are at fault not only from the standpoint of the control of the leaf spot, but from an economic standpoint as well. Even where the beet tops of several rows are thrown together, shocked, and later removed, the ground underneath these shocks is certain to be infected. The resultant beet-top hay, however, is of good quality. This method of shocking holds the disease in check much better than the very general practice of leaving all material as it falls at harvest time. When the beet tops are left scattered indiscriminately over the ground, the leaves become so brittle that they break into small fragments, thus making it impossible to remove them from the field. If such a field is pastured by sheep, much of the diseased material is trampled into the ground and there results a poor control of the disease, a great loss of nutritive material, and a packing of the soil, all of which should be avoided.

Even after all the beet tops are removed from the field there is still danger that in feeding them in a dried condition some of the material will become broken up and will not be eaten. These fragments become mixed with the manure and are returned to the land. It has been proved in recent experiments that these broken-leaf portions contain the *Cercospora* fungus in a viable condition and consequently are capable of producing infection.

Thorough control of the leaf-spot fungus is assured if the green beet tops are made into silage. In the fall of 1912 a small silo, holding approximately 3 tons, was filled with green beet tops. A few layers of straw were added to absorb the excess moisture and to prevent extreme fermentation. Five pounds of salt were also added for each ton of material. In recent tests that have been made of the silage resulting therefrom, no fungus of any kind has been found to be alive. Numerous cultures examined for living *Cercospora* spores gave negative results in all cases. A portion of the silage material was sterilized and then inoculated with a fresh culture of the leaf-spot fungus, but no growth developed. This is in great contrast to the viability of the fungus out of doors, where directly after harvest it still has almost the same vitality and vigorous growth that it evinced several months before.

It is very probable that the silo is to be the real solution of the leaf-spot problem. Some of the advantages from an economic standpoint to be gained by the proper utilization of the beet tops are given by L. S. Ware in his book, "Cattle Feeding with Sugar Beets, Sugar, Molasses, and Sugar Beet Residuum," Philadelphia, 1902, pp. 93-96.

Besides the roots proper, one may harvest a large quantity of leaves and tops. However, there are many farmers sufficiently blind to overlook the precious qualities of these portions of the plant, and allow them to remain and rot on the field without rendering other service than that of supplying a portion of certain mineral elements * * * which have been absorbed by the root during its development. The money value of these leaves when used as a fertilizer is certainly less than that which would be derived from feeding to cattle. Beet leaves and tops contain, it is true, a certain amount of salts which are useful to the soil, but on the other hand many of these mineral substances can be more advantageously utilized by feeding the leaves to cattle and collecting the manure; their fertilizing properties are not subsequently lost by the passage through the animal's body and during the interval the stock has been benefited by receiving a good, wholesome, green fodder at the very period of the year when it is most relished and is eaten with avidity. * * * Experience shows that the best results are obtained by feeding siloed beet leaves during early spring. * * * Many farmers allow sheep to run over their fields and eat the leaves during their passage. Under all circumstances such customs should be prohibited, as large quantities of leaves are necessarily trod under and are thus destroyed, which in reality means a waste, as far as their nutrient value is concerned.

An average crop of leaves and tops is stated as being about 4.8 tons to the acre.

CONCLUSIONS.

(1) The leaf-spot of the sugar beet is caused by *Cercospora beticola* Sacc., which lives through the winter upon the old beet tops of the preceding season.

(2) Results thus far obtained indicate that the organism is unable to survive a passage through the alimentary tract of cattle, sheep, and pigs. However, it is impossible to prevent waste in feeding the beet tops, and consequently all material is not eaten and may be returned in a viable condition in the manure to the land.

(3) For a thorough control of the leaf-spot the beet tops should be removed from the fields while still green and should be made into silage. *Cercospora beticola* is killed when the beet tops are siloed.

[Cfr. 121]

THE WORK OF THE HUNTLEY EXPERIMENT FARM IN 1912.¹

By DAN HANSEN, *Farm Superintendent, Office of Western Irrigation Agriculture.*

INTRODUCTION.

The work being carried on at the Huntley Experiment Farm (fig. 1) is devoted mainly to experiments with crops under irrigation. These include crop rotation and tillage methods, variety testing of field crops, and tests of fruit trees, small fruits, and vegetables.

In addition to the work on irrigated land a tract of 20 acres lying above the irrigation canal is being used for a series of experiments in crop rotation and tillage methods under the supervision of the Office of Dry-Land Agriculture, and some additional work with field crops has been conducted on other tracts above the ditch.

CONDITIONS ON THE PROJECT.

In many respects the season of 1912 was rather unusual. Spring came late, and the cold, wet weather made it difficult to get land into proper condition for seeding. In early July an unusually severe storm, which came in the form of hail on some parts of the project, damaged growing crops to some extent, but perhaps the greatest damage was done to the first cutting of alfalfa, both in the field and in the stack. The season's rainfall was somewhat above the average. A large proportion of the precipitation came during September and October and interfered seriously with the harvest of beets and other late crops.

During the year 1912 the farms on the Huntley Project for which water applications had been made comprised a total irrigable area of 20,200 acres, included in 505 farms. Of this an area of 14,425 acres

¹ Issued Apr. 12, 1913.

The Huntley Experiment Farm is located on the Huntley (Mont.) Irrigation Project, adjacent to the Osborn town site. It comprises about 200 acres of public land withheld from entry by the Department of the Interior at the time of the opening of the project, to be used as an experiment farm. Of the 200 acres, only about 86 acres are irrigable, some of the land being occupied by two railroads, the main irrigation canal, and a large waste ditch, and part of it lying above the canal. In addition to the land mentioned, a tract of 40 acres of the heavy land near the town of Worden is used for experiments in reclaiming alkaline soils. The work of the farm is under the supervision of the Office of Western Irrigation Agriculture, Bureau of Plant Industry. Other offices in the Bureau of Plant Industry and the Montana Agricultural Experiment Station are cooperating in the investigational work.

was actually irrigated, and harvests were reported from 12,742 acres. Alfalfa was planted on 1,340 acres, but was not harvested. An area of 343 acres was not reported on. In Table I is summarized the more

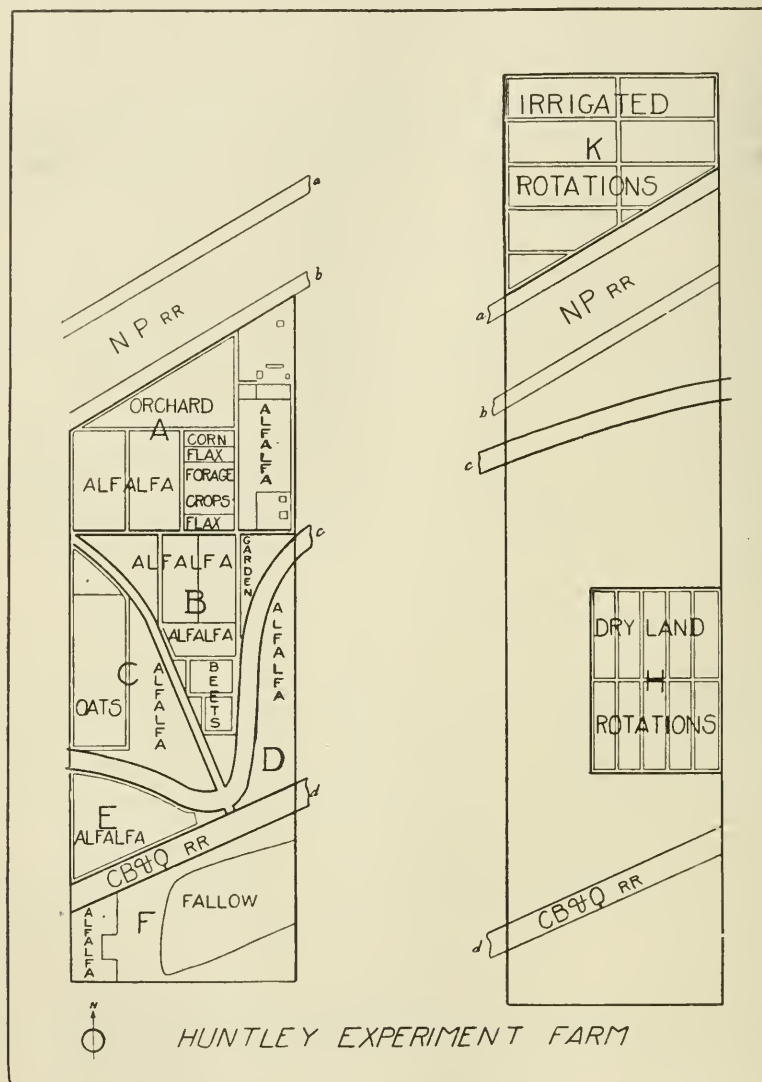


FIG. 1.—Diagram showing the location of the field experiments at the Huntley Experiment Farm in 1912, not including the Worden tract. Experiments are conducted both above and below the main canal shown at *c*.

important statistical information of the different crops on the project in 1912. The figures were furnished by the United States Reclamation Service.

TABLE I.—*Acreage, yields, and farm values of crops produced on the Huntley Reclamation Project in 1912.*

Crop.	Area (acres).	Unit of yield.	Yields.				Farm values.		
			Total.	Aver- age.	Max- imum.	Per unit of yield.	Total.	Per acre.	
								Aver- age.	Max- imum.
Alfalfa.....	3,221	Ton.....	8,930	2.60	5.70	\$7.00	\$58,730	\$18.23	\$39.90
Native hay.....	265	do.....	427	1.61	2.00	15.00	6,405	24.15	30.00
Corn.....	644	Bushel.....	4,830	7.50	40.00	.50	2,414	3.75	20.00
Grain.....	3,339	do.....	74,525	13.34	132.00	.47	35,236	10.55	42.24
Grain hay.....	525	Ton.....	415	.79	2.00	10.00	4,150	7.90	20.00
Potatoes.....	118	Bushel.....	11,125	94.27	300.00	.50	5,562	47.13	150.00
Sugar beets.....	4,660	Ton.....	38,680	8.30	18.00	6.00	232,080	49.80	108.00
Truck crops.....	170	.....	.....	.....	.....	.....	5,900	34.71	.....
Less duplications.....	200	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	12,742	.....	.....	.....	.....	.....	350,771	.....	.....
Average value per acre.....	.....	.....	.....	.....	.....	.....	.....	27.50	.....

¹ Oats.² Oats at 32 cents a bushel.

CLIMATIC CONDITIONS.

The climatological observations were made in cooperation with the Biophysical Laboratory of the Bureau of Plant Industry. Table II summarizes the observations made during the years 1911 and 1912.

TABLE II.—*Summary of climatological observations made at the Huntley Experiment Farm during the years 1911 and 1912.*

PRECIPITATION (INCHES).

Year.	Character of data.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1911		0.64	0.32	0.00	0.85	3.29	2.13	0.81	1.05	0.57	0.88	0.82	0.13	11.49
1912		.27	.21	.41	2.00	2.44	1.14	2.25	1.39	2.97	3.25	.75	.00	17.08

EVAPORATION (INCHES).

1911	.....	.....	.....	.....	4.388	5.827	7.124	8.875	6.071	5.079	2.568	.....	.....	39.932
1912	.....	.....	.....	.....	.....	4.900	7.020	6.942	6.959	3.722	2.475	.....	.....	32.018

DAILY WIND VELOCITY (MILES PER HOUR).

1911	Average.....	.....	.....	.....	5.6	5.6	4.5	4.6	4.0	4.4	4.2	5.4	5.5	.....
1912	do.....	5.6	5.2	4.8	5.8	6.3	5.2	3.9	3.7	4.2	5.6	4.2	7.8	.....
1911	Maximum.....	.....	.....	.....	9.4	8.8	8.8	8.7	7.2	9.3	10.0	11.6	11.5	.....
1912	do.....	12.8	10.8	12.1	13.0	17.5	7.7	6.0	6.5	8.0	14.7	9.7	14.6	.....
1911	Minimum.....	.....	.....	.....	2.0	1.5	2.7	2.3	2.1	1.0	1.3	1.4	1.5	.....
1912	do.....	.7	1.6	.9	2.6	1.8	2.3	.6	.8	.9	1.5	1.0	2.7	.....

TEMPERATURE (° F.).

1911	Monthly mean.....	14.2	16.1	39.1	43.2	53.8	68.5	67.6	64.1	58.2	44.8	24.9	23.6	.....
1912	do.....	16.6	29.1	18.7	46.5	55.5	66.8	67.2	66.6	50.1	44.7	38.7	29.7	.....
1911	Monthly maximum.....	50.0	40.0	74.0	77.0	92.0	94.0	97.0	97.5	94.0	84.5	55.0	55.0	.....
1912	do.....	53.0	52.0	62.0	78.0	90.0	99.5	95.0	93.0	89.0	79.0	69.0	59.0	.....
1911	Monthly minimum.....	-26	-19	-3	17.0	24.0	40.0	41.0	33.5	28.0	14.0	-20.5	-26	.....
1912	do.....	-35	-5	-27	20.0	32.0	36.0	44.0	40.0	24.0	17.0	13	1	.....

TABLE 11.—*Summary of climatological observations made at the Huntley Experiment Farm during the years 1911 and 1912—Continued.*

KILLING FROSTS.

Year.	Last in spring.		First in autumn.		Length of frost-free period.
	Date.	Minimum temperature.	Date.	Minimum temperature.	
1911.....	May 26	° F. 32	Sept. 18	° F. 28	Days. 114
1912.....	May 13	28	Sept. 16	31	125



FIG. 2.—View in field K, where the irrigated rotations are conducted. There are 29 different rotations under test, including alfalfa, sugar beets, potatoes, wheat, oats, corn, and flax.

EXPERIMENTS WITH IRRIGATED FIELD CROPS.**CROP ROTATIONS UNDER IRRIGATION.¹**

For the purpose of determining which systems of crop rotation are best suited to conditions on the project, a field containing 70 one-fourth-acre plats is devoted to a series of two, three, four, and six year rotations (fig. 2), in which the following crops are grown in different sequences: Alfalfa, sugar beets, potatoes, wheat, oats, corn, and flax.

This crop-rotation work will have to be continued for several years before results of much value can be obtained. The land on which these experiments are being conducted was planted to oats in 1911, which may explain the rather low yields of some of the crops, particularly the beets, it having been noted that beets following oats on this new ground do not as a rule give heavy yields. Table III gives the average and maximum yields obtained in the rotation experiments in 1912.

¹ These experiments were under the immediate supervision of Mr. James M. Spain.

TABLE III.—Average and maximum yields obtained in the irrigated rotation experiments at Huntley in 1912.

Crop.	Variety.	Number of plats.	Yield per acre.		
			Unit.	Average.	Maximum.
Alfalfa ¹	Montana.....	16	Ton.....	0.70	1.0
Potatoes.....	Burbank.....	13	Bushel..	244.0	413.0
Sugar beets.....	Kleinwanzlebener.....	14	Ton.....	10.3	14.37
Corn.....	Minnesota No. 13.....	5	Bushel..	36.4	42.8
Wheat.....	Pringle's Champion.....	3	do.....	25.3	31.6
Oats.....	Swedish Select.....	15	do.....	48.7	66.8
Flax.....	Minnesota No. 25.....	2	do.....	14.6	19.4

¹ Planted May 10, 1912.

METHODS AND TIME OF PLANTING ALFALFA.

In 1911 an experiment in methods and time of planting alfalfa was started on 13 one-fourth-acre plats in field A-IV. The experiment included early and late plantings, planting early with wheat as a nurse crop, and planting in rows 18 inches apart to be cultivated. The rate of seeding of alfalfa was 12 pounds per acre, except in the row plats, where it was 6 pounds per acre. In the nurse-crop plats wheat was planted at the rate of 1 bushel per acre. Table IV shows the yields obtained in 1911 and 1912 from planting by the different methods.

TABLE IV.—Yields of alfalfa, wheat hay, and wheat on field A-IV at Huntley in 1911 and 1912 in alfalfa-planting experiment.

Method and date of planting.	Yield per acre.		
	1911 (2 cuttings).	1912 (3 cuttings).	Total (2 years).
3 plats planted May 5, 1911.....	2.43	5.64	8.07
3 plats planted June 5, 1911.....	2.00	5.35	7.35
3 plats planted June 5, 1911, in 18-inch rows.....	1.75	4.98	6.73
2 plats planted May 5, 1911, with wheat as nurse crop, cut for hay.....	2.34	5.40	25.40
2 plats planted May 5, 1911:			
With wheat as nurse crop, cut for wheat.....	46.7		
.....	.....	4.93	4.93

¹ Wheat hay.² Plus 2.34 tons of wheat hay.³ Plus 46.7 bushels of wheat.

It is seen that early planting has resulted in somewhat higher yields than have been obtained from late planting. The yields secured from the row planting are noticeably low. In comparing these results with those obtained by planting the alfalfa with a nurse crop of wheat, consideration must be given to the yields of wheat and of wheat hay, as shown in Table IV. It will be noted that the alfalfa yields in 1912 on the nurse-crop plats were but little lower than those obtained where the alfalfa was planted alone.

The experiment was repeated in 1912 on field A-III. The results are shown in Table V.

TABLE V.—*Yields of alfalfa and wheat on field A-III at Huntley in 1912 in alfalfa-planting experiment.*

Method and date of planting.	Yield per acre in 1912.		
	First cutting.	Second cutting.	Total.
3 plats planted May 11, 1912.....tons..	1.46	0.70	2.16
3 plats planted June 14, 1912.....do....	.53		.53
3 plats planted June 14, 1912, in 18-inch rows.....do....	.24		.24
4 plats planted May 11, 1912: With wheat as nurse crop, cut for wheat.....bushels..			44.2

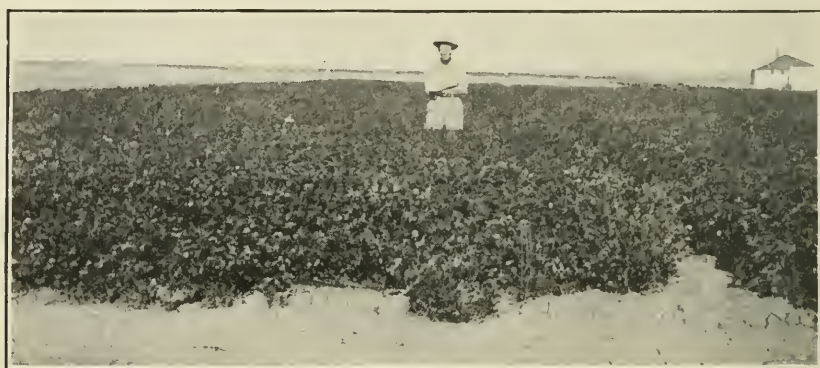


FIG. 3.—Red clover on plat A-II-8, photographed June 13, 1912. This was planted in 1911, and yielded at the rate of 3.78 tons per acre in 1912.

Table V shows that early planting resulted in higher yields than those from late planting, as was the case on field A-IV in both 1911 and 1912. The row planting yielded even less favorably on field A-III than it did on field A-IV.

All the results so far obtained favor early planting. They oppose planting in rows where irrigation is practiced and where the crop is cut for hay. Further time is required to determine the final influence of the nurse crop.

GRASS MIXTURES.

While it is recognized that alfalfa is likely to remain the leading forage crop of the project, information is often desired as to the value of other forage plants, especially grasses, clovers, and grass mixtures. Such information will be particularly useful to farmers who expect to engage in dairying and who will therefore have need for cow pastures during a part of the year. In 1911 and 1912 an experiment in which grasses and clovers (fig. 3) were tested singly and in different combinations was conducted in cooperation with the

Office of Forage-Crop Investigations, Bureau of Plant Industry.
The results obtained during the two years are given in Table VI.

TABLE VI.—Yields of grass mixtures on Field A-II, Huntley Experiment Farm, 1911 and 1912.

Plat No.	Crop or crop combination.	Yield per acre (tons).		
		1911	1912	Total (2 years).
A-II-1	<i>Bromus inermis</i> , orchard grass, tall oat-grass, meadow fescue, Italian rye-grass, timothy, redbud, Kentucky bluegrass, alfalfa, alsike clover, red clover, and white clover.....	1.31	} Plowed in the fall of 1911 because of poor stand.	
A-II-2	<i>Bromus inermis</i> , orchard grass, tall oat-grass, Italian rye-grass, alfalfa, alsike clover, and white clover.....	.86		
A-II-3	<i>Bromus inermis</i> , orchard grass, Italian rye-grass, alfalfa, alsike clover, and white clover.....	.95	3.37	4.32
A-II-4	<i>Bromus inermis</i> , orchard grass, redbud, timothy, and alsike clover.....	1.00	4.69	5.69
A-II-5	Orchard grass, Italian rye-grass, slender wheat-grass, Kentucky bluegrass, alsike clover, red clover, and white clover.....	1.59	2.02	3.61
A-II-6	Timothy and alfalfa.....	2.50	5.31	7.81
A-II-7	Timothy and red clover.....	1.65	4.05	5.70
A-II-8	Red clover.....	1.69	3.78	5.47

Plats A-II-1 and A-II-2 were planted on very heavy, low ground which was difficult to get into perfect condition for seeding, with the result that a poor stand was secured. These plats were therefore plowed up in the fall of 1911. Of the grasses in the combinations, *Bromus inermis*, orchard grass, and Italian rye-grass have made the best stand, *Bromus inermis* doing especially well.

DISTANCE OF PLANTING AND THINNING SUGAR BEETS.

Special work with sugar beets has been carried on in cooperation with the Office of Cotton and Truck Disease and Sugar-Plant Investigations. This included tests of time of irrigation and distance of planting and thinning. In the distance of planting and thinning experiment a series of 45 plats was used in 1912. Fifteen plats were planted in rows 18 inches apart, 15 plats in rows 20 inches apart, and 15 plats in rows 24 inches apart. These were thinned to 6, 9, 12, 15, and 18 inches apart in the rows. All plats were run in triplicate. The average yield from the entire series was 15.5 tons per acre. The results obtained indicate that, regardless of the distance of thinning, the 18-inch rows will give the best yields. The best combination of thinning and planting was the 18-inch rows thinned to 12 inches. The three plats planted in this way produced an average yield of 17.8 tons per acre, the highest yield obtained. There was but slight variation in the sugar content of the beets grown in the different plats, the average being 18.7 per cent.

In the irrigation test with beets it was impossible to follow the plan as outlined, because of the unusually copious rains during the season; therefore, the differences in the yields obtained in 1912 were not significant.

IRRIGATION TESTS WITH FLAX.

At the request of the Montana Agricultural Experiment Station, a series of 10 one-tenth-acre plats was devoted to an irrigation test with flax (fig. 4). The purpose was to determine the amount of water best suited to this crop and the proper time of applying water. The plan of this experiment was to give one, two, and three irrigations at different stages of plant growth on the different plats—in one case to give but one irrigation, and that before planting. The unusual weather conditions, especially the heavy rain in early July, tended to bring on all plats uniformly, so that the results obtained would not apply to the average season. It was possible, however, to test the effect of late irrigation. Plats irrigated after the flax was well through the bloom did not show any tendency to start a second growth and were not held back in ripening, all plats being ready for harvest on about the same date. It may be, however, that this would



FIG. 4.—Plats of flax in field A 11, used in the experiment with time of irrigation. The average yield of the 10 plats in this experiment in 1912 was 18.6 bushels per acre.

not apply to a large field, especially one that was not perfectly drained and where the water was permitted to stand for any length of time. The average yield of all the plats was at the rate of 18.6 bushels per acre, and variations from this were so slight that they could not properly be attributed to differences in treatment.

FIELD CORN.

A test to determine the earliest and best-yielding varieties of corn suitable for use on the project and in the rotation experiments was carried on during 1912 in cooperation with the Office of Corn Investigations. The varieties yielded as follows: Northwestern Dent, 58.3 bushels; Brown County Yellow, 51.5; Wisconsin No. 7, 61.8; Minnesota No. 13, 59; Minnesota No. 23, 51.7; and Selection No. 133, 62.9 bushels per acre. The average yield of all the varieties was 57.5 bushels per acre. The first three varieties matured better than the others. On account of their earliness they are more promising for the Huntley Project. The Northwestern Dent and the Brown County Yellow were the best varieties tested in 1912.

ORCHARD AND SMALL-FRUIT TREES.

In the spring of 1911 a 5-acre tract was planted to about 100 varieties of apples, cherries, and plums, together with 26 varieties of small fruits.¹ The unusually severe weather of the winter of 1911-12 injured many of the trees, especially apples and cherries, and it was necessary to replant about half the trees in the spring of 1912. All trees made good growth during the season. Small fruits came through the winter in good condition.

RECLAMATION OF THE WORDEN TRACT.

Some of the land in the Huntley Project is heavy clay, carrying more salt than is tolerated by most crop plants. This salty condition is due chiefly to the impervious character of the soil and the

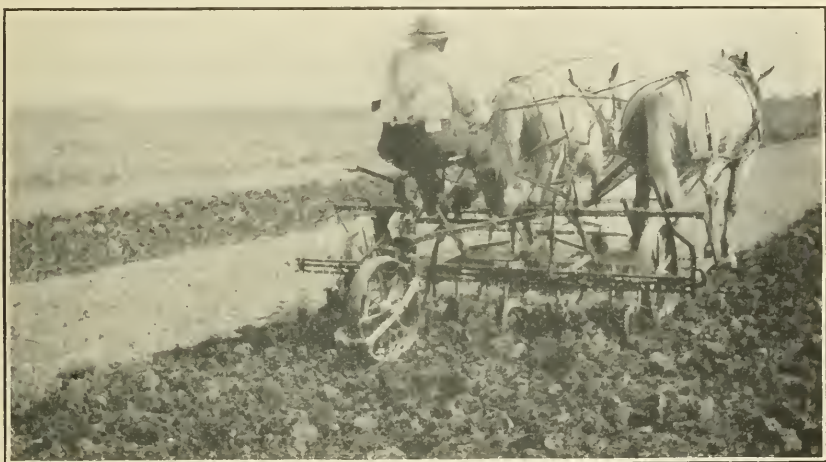


Fig. 5.—Cultivating plats in field M, Worden tract, in the test of alternate irrigation and cultivation. The salt content of the surface 12 inches of soil has been reduced in one year from an average of 0.52 per cent to 0.28 per cent.

consequent lack of leaching by the rains. The subsoil at a depth of about 6 feet is a porous gravel, and the chief problem is to get the surface soil opened up and supersaturated with water to bring about artificial leaching.

In 1910, 12 acres of a 40-acre tract of typical heavy land near the Worden town site were broken up, and experiments have been carried on there to determine the best means of reducing the salt content and bringing the land into production.

One method employed was to level the ground in plats of about one-fourth of an acre each, around which a border was made, and to practice on these plats a system of alternate light irrigation and cultivation (fig. 5). This work has been carried on but one full

¹ These varieties were selected upon the advice of Mr. H. P. Gould, of the Office of Field Investigations in Pomology.

season, but salt determinations made at different times show a decided reduction in the salt content of the upper 12 inches of soil. The average salt content of the upper 12 inches of soil on plats M-I-5 to M-I-9, inclusive, in September, 1911, was 0.52 per cent. By September, 1912, the percentage of total salts in the same plats had been reduced to an average of 0.28.

About 10 acres of the land have been planted to winter rye for two seasons. Both crops of rye were produced without irrigation, the winter rains and snows giving sufficient moisture. The crop was plowed under in May each year and the land kept in good tilth throughout the remainder of the season in order to prevent the evaporation of water from the surface and the consequent accumulation of salt in the upper layer of the soil.

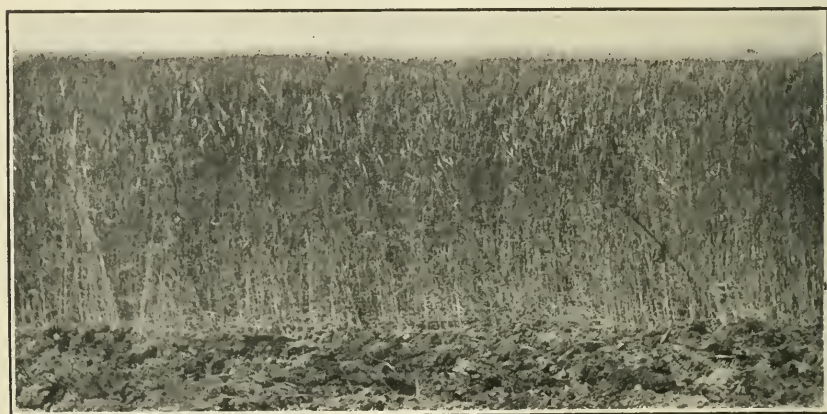


FIG. 6. A plat of rye on the Worden tract in May, 1912. Rye was grown here in 1911 and 1912, the second crop being heavier and more uniform than the first. The green crop has been plowed under each year to improve the physical condition of the surface soil.

Salt determinations have not been systematically made on the rye land, so that it is not known to what extent the salt content of the surface soil has been reduced. The growth of rye (fig. 6) was much heavier and more uniform in 1912 than it was in 1911, and the soil tilth was decidedly better, so that the plowing under of the rye crop appears to have had a beneficial effect. During the season of 1913 salt determinations will be made regularly and the salt content of the rye land will be compared with that of the adjacent virgin soil.

METHODS OF SECURING SELF-POLLINATION IN COTTON.¹

By ROWLAND M. MEADE, *Scientific Assistant, Office of Crop Acclimatization and Adaptation Investigations.*

The advantage of being able to prevent cross-pollination and thus insure pure seed is recognized by all cotton breeders. Various methods have been used, both in this country and abroad. Some experimenters have gone so far as to cover single plants with cages of fine-mesh wire or cloth in order to prevent the visits of insects to the flowers. This method may be very convenient when pure seed is desired from a single plant only, but is scarcely practicable for whole rows or bulk plantings. The expense of covering the plants is great, and if the mesh of the screen is fine enough to exclude thrips and other very small insects the conditions of growth are affected, so that the plants may not develop normally.

The method of bagging the flowers has been used most extensively. A small paper bag is inflated and placed over a flower bud and the mouth of the sack is tied with string or wire about the pedicel. Flowers covered in this manner open naturally inside the sacks, and the pollen is distributed from the anthers as freely as in uncovered flowers. Within a few days after fertilization has been accomplished, the paper sacks are again removed to allow normal development of the young boll. The first operation of adjusting the sacks is one that requires some time and skill, while the operation of removing the sacks greatly increases the labor and requires additional time.

Another method has been described by Mr. W. W. Gilbert, of the Bureau of Plant Industry, in the Proceedings of the American Breeders' Association, vol. 8, 1912. Briefly, it consists of coiling a fine, soft copper wire in a spiral about the enlarging flower bud, making one end fast near the base of the petals and bending the other end double over the tip of the bud. This coil keeps the petals from opening and the doubled end prevents the entrance of insects. The wire falls away with the petals, which avoids a second operation like that of removing the bags.

The work of coiling and adjusting the wires can also be saved by using other devices for holding the petals together. Dr. D. A. Saunders, of this Bureau, has found it possible to use small rubber bands instead of the coiled wires. The band is snapped over the upper end of the flower bud and does not allow the petals to open, but permits sufficient expansion of the petals for the normal development of the

stamens and anthers. A great many flowers may be treated in this manner in a short time, for only a few seconds are required to snap the bands over the buds.

An equally simple and efficient method employs a familiar paper clip of the form in common office use. The sides of the clip are separated and the ends spread out as in figure 1, *A*. This is then

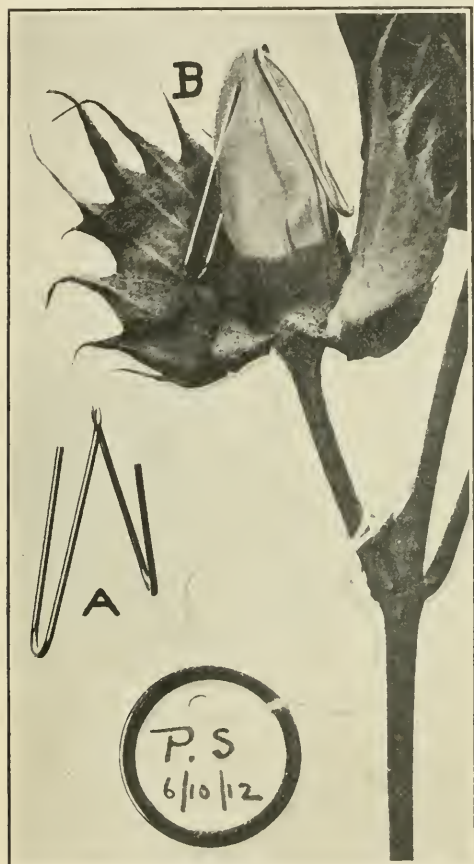


FIG. 1.—(*A*) Wire paper clip adjusted for placing on cotton bud. (*B*) Unopened flower bud with wire clip in position to prevent the separation of the petals. (Natural size.)

placed over the end of the bud so that the tip of the bud projects through the loop of the clip and is held by a free end and one side of the clip. (See fig. 1, *B*.) The petals can expand to a certain extent, but the clip holds them together sufficiently to prevent their opening. Enough space is provided for the normal development of the stamens, and pollination is assured. This method has an advantage over the rubber-band scheme in its manner of securing the petals. The clip holds the petals lengthwise and does not slip off, while the rubber band secures the petals laterally and is sometimes forced off by the expanding bud.

Further modifications of these methods may be possible without changing results. Any appliance that can be placed over the bud to prevent its opening and still allow sufficient expansion of the petals for the normal

development of the stamens and pistil will provide all the requirements that insure self-fertilization in the cotton flower. Any of these methods may also be used to prevent the opening of a flower from which pollen is to be taken in hybridizing work. The advantages of these simplified methods will be most readily appreciated by breeders who wish to maintain a pure line of cotton, as they make it possible to secure a larger quantity of pure seed in a limited time.

U. S. DEPARTMENT OF AGRICULTURE.

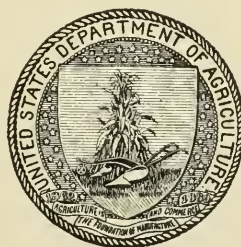
BUREAU OF PLANT INDUSTRY—Circular No. 122.

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

Directions for Blueberry Culture	FREDERICK V. CLEVELLE
The Work of the Truckee-Carson Experiment Farm in 1912	F. B. HEADLEY
Feterita, a New Variety of Sorghum	{ H. N. VINALL and CARLETON R. BALL

Issued April 19, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1913.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, WILLIAM A. TAYLOR.
Assistant Chief of Bureau, L. C. CORBETT.
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[Cir. 122]

DIRECTIONS FOR BLUEBERRY CULTURE.¹

By FREDERICK V. COVILLE, *Botanist in Charge of Taxonomic and Range Investigations.*

SPECIAL REQUIREMENTS.

Success in blueberry culture rests especially on the recognition of two peculiarities in the nutrition of these plants: First, their requirement of an acid soil; secondly, their possession of a root fungus that appears to have the beneficial function of supplying them with nitrogen.²

If blueberries are planted in a soil with an alkaline or neutral reaction, such as the ordinary rich garden or fertile field, it is useless to expect their successful growth. In such a situation they become feeble and finally die. Blueberries require an acid soil, and they thrive best in that particular type of acid soil which consists of a mixture of pure sand and peat. The peat may be of either the bog or the upland sort.

Good aeration of the soil is another essential. It is commonly but erroneously supposed that the swamp blueberry (*Vaccinium corymbosum*), the species chiefly desirable for cultivation, grows best in a permanently wet soil. It is to be observed, however, that the wild plants of the swamps occupy situations which, though perhaps submerged in winter and spring, are exposed during the root-forming period of summer and autumn or, when growing in permanently submerged places, they build up a hummock or a cushion of moss which rises above the summer water level and within which the feeding roots of the bush are closely interlaced. In actual culture, moreover, it has been found that the swamp blueberry does not thrive in a permanently wet or soggy soil.

Although some species of *Vaccinium*, such as the common low-bush blueberry (*V. pennsylvanicum*), grow and fruit abundantly in sandy uplands that are subject to drought, the swamp blueberry grows best in soils naturally or artificially supplied with adequate moisture.

¹ Issued Apr. 19, 1913.

² For a full discussion of the principles of blueberry culture, including the soil requirements and peculiarities of nutrition of the blueberry plant and the details of the growing of seedlings, consult Experiments in Blueberry Culture, Bulletin 193, Bureau of Plant Industry, 1911.

These, then, are the three fundamental requirements of successful blueberry culture: (1) An acid soil, especially one composed of peat and sand, (2) good drainage and thorough aeration of the surface soil, and (3) permanent but moderate soil moisture. Under such conditions the beneficial root fungus which is believed to be essential to the nutrition of the plant need give the cultivator no concern, for it will propagate itself spontaneously and adequately without any necessity of soil or plant inoculation.

VALUE OF SUPERIOR STOCKS.

Blueberry plantations may be formed by the transplanting of unselected wild bushes or by the growing of seedlings, but such a course is not the best. Seedling plants, even from the largest berried parents, produce small berries oftener than large ones. Until nursery-men are prepared to furnish plants asexually propagated from superior stocks, the cultivator should begin by the transplanting of the best wild bushes, selected when in fruit for the size, color, flavor, and earliness of the berry, and the vigor and productiveness of the bush. These he should propagate by layering and by cuttings until his plantation is completed. Through a combination of these two methods, a valuable old plant can be multiplied by several hundred at one propagation, the fruit of the progeny retaining all the characteristics of the parent.

Large berries cost less to pick than small ones and bring a higher price. A berry eleven-sixteenths of an inch in diameter has already been produced under cultivation and others of still larger size are to be expected.

PROPAGATION.

While grafting and especially budding are useful in experimental work, neither method is suitable for commercial plantations because blueberry bushes are continually sending up new and undesirable shoots from the stock. For experimental purposes the best season for budding is from the middle of July to the end of August. The budded plants should be protected from direct sunlight, and special care should be taken that the raffia wrapping does not become wet for the first three weeks.

STUMPING.

The easiest way to propagate the swamp blueberry is by a special process of layering named "stumping." The directions are as follows:

1. In late fall, winter, or spring, preferably in early spring before the buds have begun to push, cut off at the surface of the ground either the whole of

the plant or as many of the stems as it is desired to devote to this method of propagation. The stems that are cut off are discarded, or they may be used for cuttings, as described under "Tubering."

2. Cover the stumps to the depth of 2 to 3 inches with a mixture of clean sand and sifted peat, about 4 parts of sand to 1 of peat, by bulk. A rough box or frame may be built on the ground to keep the sand bed in place.

3. Care must be taken that the sand bed be not allowed to become dry, except at the surface, during the summer.

4. The new growth from the stumps, which without the sand would consist of stems merely, is transformed in working its way through the sand bed into scaly, erect or nearly erect rootstocks which, on reaching the surface of the sand, continue their development into leafy shoots. Although roots are formed only sparingly on the covered bases of stems, they develop abundantly during spring and early summer on these artificially produced rootstocks, and by the end of autumn all the shoots should be well rooted at the base. They should remain in place in the sand bed till late winter or early spring, undisturbed and exposed to outdoor freezing temperatures, but the sand mulched with leaves, preferably those of red oaks.

5. Early in the following spring, before the buds have begun to push, open the bed and sever each rooted shoot carefully from the stump. Discard the upper portion of the shoot, making the cut at such a point as to leave on the basal portion about three buds above the former level of the sand bed. If the cut at the basal end of the rooted shoot is not smooth or the wood is cracked, recut the surface with a sharp thin-bladed knife. The discarded upper portion of the shoot may be used for cuttings, as described under "Tubering."

6. Set the rooted shoots in a cold frame or a cool greenhouse in clean earthenware pots of suitable size, ordinarily 3-inch pots, in a soil mixture consisting of 2 parts of rotted upland peat, by bulk, to 1 part of sand and 1 part of clean broken crocks.

7. Cover the frame with a painted sash or with thin muslin, giving the plants plenty of light but no direct sunlight, and for the first two or three months keep the temperature at not to exceed 65° F. if practicable. When subjected to high temperatures the newly cut shoots are liable to die and rot from the base upward. The outer surface of the pots should never be allowed to become dry. The desired condition may be assured by bedding the pots in moist sand up to the rim.

8. Watering should be as infrequent as practicable, only sufficient to keep the soil moist but well aerated.

9. The frame should receive ventilation, but not enough to cause the new twigs to droop. These are most susceptible to overventilation and to overheating when they have nearly completed their growth.

10. After the new twigs have stopped growing and their wood becomes hard, new root growth takes place. Then secondary twig growth follows, either from the apex of the new twigs or from another bud lower down on the old wood of the original rooted shoot. Until this secondary twig growth takes place the life of the plant is not assured.

11. Those plants that make sufficient growth to require repotting during the first summer should be set in clean pots of 2 inches larger diameter in a standard blueberry soil mixture.

SOIL MIXTURE FOR BLUEBERRIES.

A very successful potting mixture, or nursery-bed mixture, for blueberry plants consists of one part of clean or washed sand, nine parts

of rotted upland peat, either chopped or rubbed through a sieve, and three parts of clean broken crocks. No loam, and especially no lime, should be used. Manure is not necessary, and in the present state of our knowledge may be regarded as dangerous, although in small amounts it serves to stimulate the plants, at least temporarily. The danger from manure apparently lies in its tendency to produce an alkaline condition in the soil.

The use of broken crocks in the potting mixture is based on the fact that the rootlets seek them and form around them the same kind of mats that they form at the wall of the pot, thus increasing the effective root surface and the vigor of growth.

The peat most successfully used for potting blueberry plants is an upland peat procured in kalmia, or laurel, thickets. In a sandy soil in which the leaves of these bushes and of the oak trees with which they usually grow have accumulated and rotted for many years untouched by fire, a mass of rich leaf peat is formed, interlaced by the superficial rootlets of the oak and laurel into tough mats or turfs, commonly 2 to 4 inches in thickness. These turfs, ripped from the soil and rotted from two to six months in a moist but well-aerated stack, make an ideal blueberry peat. A good substitute is found in similar turfs formed in sandy oak woods having an underbrush of ericaceous plants other than laurel. Oak leaves raked, stacked, and rotted for about 18 months without lime or manure are also good. The leaves of some trees, such as maples, rot so rapidly that within a year they may have passed from the acid condition necessary for the formation of good peat to the alkaline stage of decomposition, which is fatal to blueberry plants. Even oak leaves rotted for several years become alkaline if they are protected from the addition of new leaves bearing fresh charges of acidity.

TUBERING.

By ordinary methods, cuttings of the swamp blueberry have been rooted only in occasional instances. Two successful methods, however, have been especially devised for these plants. The most novel of these but the one easiest of operation is that of "tubering." This method involves the same principle as that employed in stumping, namely, the forcing of new shoots in such a manner that their basal portions are morphologically scaly rootstocks, with a strong rooting tendency. The directions for tubering as applied to the swamp blueberry are as follows:

1. Make stem cuttings from outdoor plants between midwinter and early spring, before the buds have begun to make their spring growth, and preferably on a warm day when the twigs are not frozen. A still better plan is to make the cuttings in autumn after the leaves have fallen, and store them for

about two months in moist sphagnum on ice at a temperature just above freezing.

2. The cuttings are to be made from vigorous plants grown in well-lighted situations and with stems therefore well stored with starch. Use unbranched portions of the old and hardened branches and stems, about a quarter of an inch to an inch or even more in diameter. Three to four inches is a suitable and convenient length. Make the cuts with pruning shears or a fine-toothed saw and remove the bruised wood at the cut ends with a sharp knife. Be careful not to injure the bark or split or strain the wood.

3. Lay the cuttings horizontally in a shallow box or other cutting bed of pure clean sand and cover them to the depth of about half an inch. Moisten the sand well with rain water, bog water, or other pure water (free from lime) from a sprinkling pot, and see that the sand is closely and firmly packed about the cuttings. Cover the box or cutting bed with a pane or panes of glass, the top of the box being flat, so that the glass fits it rather tightly. The box should be so prepared that any surplus water in the sand will drain away beneath through holes in the bottom covered with clean broken crocks and sphagnum moss.

4. Keep the box at a temperature of 55° to 65° F., or as near those limits as practicable. A temperature of 70° or over is likely to ruin the cuttings.

5. In order to avoid excessive temperatures, do not allow direct sunlight upon the glass, either keeping the box by north light or keeping it shaded, as by a white cloth or paper cover suspended several inches above the glass or in a shaded greenhouse.

6. Keep the air inside the box saturated with moisture. This condition will be evidenced by the condensation of the moisture on the under side of the glass during the cooler part of the day or whenever a cold wind blows against the glass.

7. Watering should be as infrequent as practicable, only sufficient to keep the sand moist but well aerated and the atmosphere in the box saturated. If the glass fits tightly, a second watering may not be needed for several weeks, when ventilation of the growing shoots has reduced the moisture of the cutting bed.

8. Within a few weeks new growth will begin to appear above the sand. Ventilation may then be given by sliding the glass until a crack is left open at one side of the box, but the air beneath the glass should still remain in a condition of approximate saturation. If the new growth starts to wilt, reduce the ventilation till the wilting ceases.

9. When the shoots have reached a length proportionate to their vigor, commonly 1 to 3 inches, their further growth is self-terminated by the death of the tip. After the leaves have reached their full size and acquired the dark-green color of maturity the time has come for the development of roots.

10. When the first shoot has reached this rooting stage a half-inch layer of finely sifted rotted peat, 2 parts, and clean sand, 1 part, should be placed on the surface of the cutting bed and moistened well with water.

11. The new growth, which if it had originated above the sand would be a true stem, like an ordinary shoot, was transformed in working its way through the sand and became a scaly erect rootstock, which on reaching the surface of the sand continued its development into a leafy shoot. During the spring and early summer roots form in abundance on the lower or rootstock portion of these shoots.

12. After a shoot is well rooted it makes secondary twig growth, usually from a bud in the axil of the uppermost leaf. If the rooting of the shoot has

not already been ascertained by direct examination, the making of such secondary growth is good evidence that rooting has actually taken place.

13. When a shoot is well rooted, with roots 1 to 2 inches in length, it is ready to be potted. If the shoot has not already disconnected itself from the dead cutting, it should be carefully severed with a sharp knife. In the process of tuberizing, the behavior of the cuttings is essentially identical with that of real tubers, like those of the potato. The original cutting dies, but the sprouts that arose from it root at the base and form independent plants.

14. The rooted shoots should be potted in clean 2-inch earthenware pots in the standard blueberry soil mixture already described.

15. The pots should be bedded in moist sand up to the rim in a glass-covered, ventilated box, well lighted, but protected from direct sunlight.

16. In order to secure rapid growth, the rooted plants should be gradually accustomed to half sunlight and a well-ventilated atmosphere, this adjustment extending over a period of about three to four weeks.

17. If preferred, the shoots may remain in the original cutting bed until the following spring before potting, the cutting bed being exposed during the winter to freezing temperatures.

TREATMENT OF YOUNG PLANTS.

When blueberry plants, either large or small, are grown in porous pots the surface of the pot should never be allowed to become dry, for the rootlets which grow through the soil to the wall of the pot for air are exceedingly fine and easily killed by drying, to the great injury of the plant. This danger may be eliminated by bedding the pots to the rim in a well-drained bed of sand or by setting the pot in another pot of 2 to 4 inches greater diameter, with a packing of moist sphagnum between and broken crocks at the bottom.

A burning of the young leaves and growing tips of twigs is often produced by the hot sun from the middle of June to the middle of September. Plants in pots or nursery beds are easily protected from such injury and forced to their maximum growth by a half-shade covering of slats, the slats and the spaces between being of the same width. On cloudy days the shade should be removed. It should not be used in fall or spring.

During the winter the rooted cuttings or 1-year-old plants should be kept outdoors, exposed to freezing temperatures, their soil mulched with leaves, preferably oak leaves. When kept in a warm greenhouse during the winter they make no growth before spring. Even then their growth is abnormal, often feeble, or sometimes deferred for a whole year.

FIELD PLANTING.

Plants from cuttings or rooted shoots are ready for permanent field planting when they are 2 or 3 years old and about 1½ to 2 feet high. They are best set out in early spring, before the buds have begun to push.

It is a curious fact that these plants send out no new roots in spring until they are in full leaf, their flowering is nearly or quite finished, and their principal twig growth has ceased. It is important, therefore, in taking up either a wild or a cultivated plant from the open ground that as much as possible of the old root mat be lifted with the plant, for upon this they depend for moisture until their new rootlets are formed.

In the case of mature wild bushes with very large root systems, when it is practicable to secure but a fraction of the root mat, say, a disk only 3 or 4 feet in diameter, it is the best procedure to cut all the stems to the ground at the time of transplanting. The bush will then produce a new and symmetrical top of a size suited to the capacity of the roots. The wood that is removed may be used for cuttings if the plant is sufficiently valuable.

In the permanent field plantation the bushes should be set 8 feet apart each way. When they reach mature size they will nearly or quite cover the intervening spaces.

To secure full vigor of growth the ground between the bushes must be kept free from all other vegetation. On rocky uplands a continuous mulch of oak leaves, when it is practicable to secure them, will help toward this end as well as keep the soil in the necessary acid condition. It is more economical, however, to choose such a location for the plantation as will permit the use of horse-drawn machinery and will make mulching unnecessary.

The most favorable location for blueberry culture is a boggy area with a peat covering and sand subsoil, the peat preferably of such a thickness that a deep plowing will turn up some of the underlying sand.

The land should be so ditched that the water level can be kept at least a foot below the surface of the ground during the growing season or can be raised for subirrigation during a drought.

The ground should be plowed to the depth of about 8 inches and repeatedly harrowed or otherwise tilled during the season preceding the planting, in order to kill the vegetation. The best time for plowing is late spring, after the principal vegetation has used up its stored starch in completing its early growth and before the leaves have matured and the roots have begun the new storage of starch with which they can send up new sprouts. After the plants are old enough to have formed a root mat, the tillage should be very shallow, not more than 2 or 3 inches, so that the roots will not be injured. This is probably best accomplished by the use of a light spring-tooth harrow with the teeth set closer together than usual.

Fertilizer experiments have shown that lime is positively injurious and that manure, while producing a temporary stimulation of vege-

tative growth, is likely to cause serious injury later. For those desiring to experiment with fertilizers the following acid mixture is recommended, applied at the rate of 1,000 pounds per acre, or one-fifth of a pound per square yard:

	Pounds.
Acid phosphate (high grade, about 16 per cent available phosphoric acid)	600
Sulphate of potash (50 per cent potash)	200
Sulphate of ammonia (20 per cent nitrogen)	200
(Muriate of potash may be substituted for sulphate of potash.)	

This and similar acid mixtures have been used with success on blueberry plants, in both pot and field experiments, with no evidence thus far of cumulative injurious effects. However, as no fertilizer is required to make the swamp blueberry fruit abundantly and continuously in suitable peat and sand soils properly handled, the use of fertilizers in commercial plantations is not at present advocated.

The swamp blueberry does not require a yearly pruning. When one of the stems of a bush becomes unproductive from injury or old age it should, of course, be cut out. If a large part of a bush needs removal it is better to cut all the stems to the ground and let the plant send up new shoots all of the same age to form a wholly new and symmetrical top.

YIELD AND PROFITS.

By proper manipulation in the greenhouse, seedling blueberry plants can often be made to ripen a few berries in less than a year, but they do not come into commercial bearing in field plantations until they are about 5 years old, when the plants are 3 to 4 feet high. They then increase slowly to full size and full bearing. Wild bushes of the swamp blueberry live to great age, often 50 to 100 years, still bearing heavily. Individual stems may remain productive for 10 to 25 years. When dead they are replaced by new and vigorous shoots from the root.

The field plantings resulting from the recent experiments in blueberry culture are too young to show the mature yield. Fortunately, however, there has been found, near Elkhart, Ind., a small blueberry planting of mature age, believed to be the only commercial plantation in existence. The returns from this plantation set forward our knowledge of yields by at least a decade. The plantation is a little less than 2½ acres in extent. It was started in 1889 in a natural blueberry bog, which was first drained and then set with unselected wild blueberry bushes. The plantation was profitable from the first, but exact records of yield and receipts are available only for the years

1910 to 1912, when the plantation was 21 to 23 years old. The data are as follows:

Yield and receipts from plantation of blueberries near Elkhart, Ind., 1910 to 1912.

Year.	Yield per acre.	Price (ap- proximate average per quart).	Receipts per acre.	Profits per acre.
1910 (a year of "almost total failure" because of late spring freezes).....	<i>Quarts.</i> 419	<i>Cents.</i> 17 $\frac{1}{2}$	\$71.87	\$10
1911.....	2,266	12 $\frac{3}{4}$	292.44	139
1912.....	2,379	12 $\frac{3}{4}$	305.75	147

The annual expenses for weeding, cultivation, and irrigation were about \$20 per acre. The cost of picking was 5 cents a quart. The general cost of maintenance of the equipment was about \$2 per acre per year, the crates and boxes being used repeatedly. The computation includes an estimated annual charge of \$12 per acre for interest, \$2 for taxes, and \$4 for depreciation or sinking fund.

It must be borne in mind that these figures are based on the yields from wild bushes transplanted without selection as to individual productiveness or the size of the berries. With bushes propagated from selected stocks the yield should be greater and the berries much larger, this greater size probably effecting a reduction in the cost of picking and certainly an increase in the selling price.

Only a beginning has been made in the improvement of the blueberry. In a series of experiments involving the selection of superior wild strains, the growing of hybrids, and the forcing of choice varieties to quick fruiting by budding them on strong seedling stocks, berries eleven-sixteenths of an inch in diameter have already been produced, and it is expected that from the better wild stocks now available berries of still larger size will be developed.

[Cir. 122]

THE WORK OF THE TRUCKEE-CARSON EXPERIMENT FARM IN 1912.¹

By F. B. HEADLEY, *Farm Superintendent, Office of Western Irrigation
Agriculture.*

INTRODUCTION.

The Truckee-Carson Experiment Farm² was established by the Bureau of Plant Industry of the Department of Agriculture in 1906 on 160 acres of land 1 mile south of Fallon, Nev. The land was withdrawn from entry by the Reclamation Service for use as an experiment farm.

The Truckee-Carson Project is situated in one of the driest regions in the United States, the average annual rainfall being less than 5 inches. The native vegetation of the project is extremely sparse, so that the virgin soil is lacking in vegetable matter. Furthermore, the high evaporation has resulted in the accumulation of alkali salts in the surface soil on many parts of the project.

Since irrigation was commenced several years ago, surplus water has accumulated in many of the low-lying lands and a water table has thus been established. In certain parts of the project this water table is within 2 to 4 feet of the surface and its presence has a detri-

¹ Issued Apr. 19, 1913.

² The Truckee-Carson Experiment Farm is maintained by the Office of Western Irrigation Agriculture of the Bureau of Plant Industry. For a report on the work of the farm previous to 1909, see Scofield, C. S., and Rogers, S. J., "The Truckee-Carson Experiment Farm." U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 157, 1909. More recent publications relating to the investigational work are as follows:

U. S. Department of Agriculture, Bureau of Plant Industry:

Bulletin 211, 1911. Bacteriological studies of the soils of the Truckee-Carson Irrigation Project, by K. F. Kellerman and E. R. Allen.

Circular 91, 1912. The nematode gallworm on potatoes and other crop plants in Nevada, by C. S. Scofield.

Circular 110, p. 21-25, 1913. Agriculture on the Truckee-Carson Project: Vegetables for the home garden, by F. B. Headley and Vincent Fulkerson.

Circular 113, p. 15-22, 1913. Commercial truck crops on the Truckee-Carson Project, by F. B. Headley and Vincent Fulkerson.

Circular 114, p. 25-30, 1913. Climatic conditions on the Truckee-Carson Project, by F. B. Headley.

Circular 118, p. 17-28, 1913. Fruit growing on the Truckee-Carson Project, by F. B. Headley and Vincent Fulkerson.

The arrangement of the fields and the location of the crop experiments in 1912 are shown in figure 1.

mental effect on the soil and on crops. The three conditions above enumerated, namely, the general lack of vegetable matter in the soil, the presence of harmful quantities of alkali salts, and the existence of a high water table, determine the nature of most of the problems of crop production on the project. The investigations conducted at the experiment farm have been concerned largely with these three conditions. (Fig. 1.)

One of the first requisites of successful crop production on the project is to get the soil well supplied with vegetable matter, and the

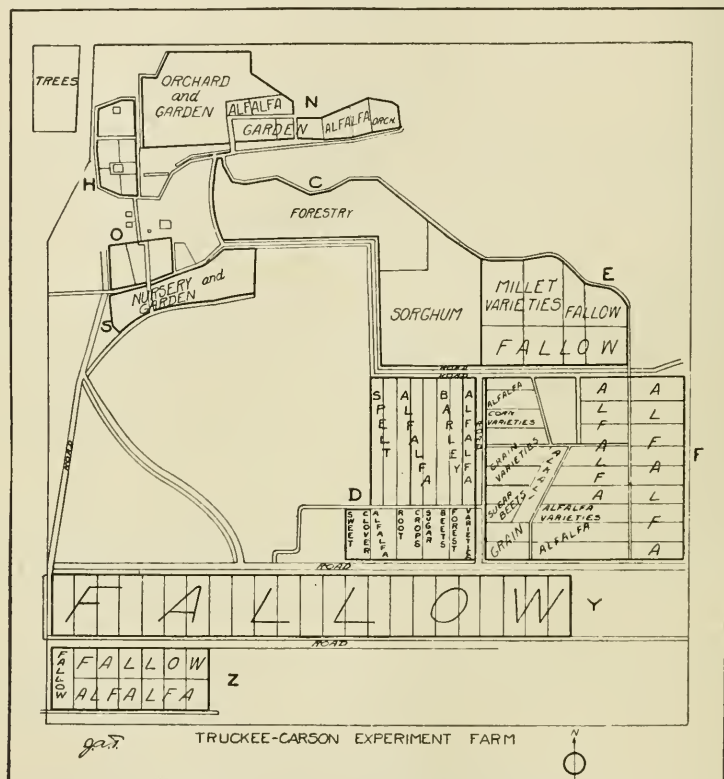


FIG. 1.—Diagram of the Truckee-Carson Experiment Farm, showing the arrangement of the fields and the location of the crop experiments in 1912.

most practical method of accomplishing this is to get a crop of alfalfa established on the land. This has been one of the principal aims of the work at the experiment farm. Numerous experiments have been conducted with a view to reducing the salt content of the soil, and in 1912 a pumping plant was installed for the purpose of lowering the level of the ground water.

The question of marketing crops is also an important one to the farmers on the project. The local market demands are so limited

that it will be necessary for the farmers to produce crops which can be profitably shipped to distant points. Commercial truck crops, such as potatoes, onions, and melons, are very promising in this connection, and much of the work of the experiment farm has been devoted to the testing of varieties and cultural methods for these crops.

Some work of an educational nature is done among the local farmers. Instruction and demonstrations are given in connection with the proper methods of tree planting, pruning, and spraying, and an active part is taken in the local agricultural fairs. Some attention has been given to finding what shade and ornamental trees and other plants could best be used in beautifying home grounds. (Fig. 2.)

CLIMATIC RECORDS.

Daily records are kept of the maximum and minimum temperatures, humidity, precipitation, evaporation, and wind velocity. This work is carried on in cooperation with the Biophysical Laboratory of the



FIG. 2.—A hedge of oleaster on the Truckee-Carson Experiment Farm. For ornamental purposes and as a windbreak oleaster is one of the most desirable plants tested at the farm.

Bureau of Plant Industry. A meteorograph has been installed on the experiment farm by the University of Nevada. This instrument records automatically on a single sheet of paper the relative humidity, temperature, barometric pressure, wind velocity, and wind direction.

Table I gives a summary of the climatological observations made since 1906.

TABLE I.—*Summary of climatological observations at the Truckee-Carson Experiment Farm, 1906 to 1912, inclusive.*

PRECIPITATION (INCHES).

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for 7 years, 1906 to 1912...	0.76	0.30	0.53	0.53	0.36	0.35	0.06	0.09	0.34	0.41	0.21	0.60	4.54
For the year 1912...	.13	.06	.37	.87	.43	.22	.13	.18	.43	1.10	.08	(¹)	4.00

TABLE I.—*Summary of climatological observations at the Truckee-Carson Experiment Farm, 1906 to 1912, inclusive—Continued.*

EVAPORATION (INCHES).

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for 5 years, 1908 to 1912.....	1.24	1.96	3.52	5.93	7.97	10.22	10.64	9.80	6.06	3.71	2.13	0.80	64.01
For the year 1912.....	1.24	2.13	4.15	5.66	7.40	10.39	9.64	9.03	6.07	3.43	1.97	.78	61.89

DAILY WIND VELOCITY (MILES PER HOUR).

Monthly average:													
4 years, 1909 to 1912.....	3.33	3.74	4.87	5.54	4.89	4.88	3.46	3.66	3.67	3.37	3.46	3.04	.....
For the year 1912.....	3.20	3.44	5.70	6.02	4.00	5.25	3.70	3.62	3.57	3.61	3.40	3.22	.....

SKY.

Conditions in 1912:													
Days clear.....	13	14	13	16	22	22	23	27	22	18	18	18	226
Days partly cloudy.....	6	7	7	5	5	4	3	2	3	5	6	9	62
Days cloudy.....	12	8	11	9	4	4	5	2	5	8	6	4	78

TEMPERATURE (° F.).

Absolute maximum:													
7 years, 1906 to 1912.....	70	72	79	89	102	101	101	103	95	88	81	72	.....
For the year 1912.....	70	64	70	76	86	96	100	97	90	78	72	58	.....
Absolute minimum:													
7 years, 1906 to 1912.....	-15	-12	9	13	25	33	38	36	26	15	-1	-3	.....
For the year 1912.....	-7	8	9	22	29	36	38	39	29	19	13	1	.....
Mean:													
7 years, 1906 to 1912.....	31.34	37.46	43.53	50.95	56.06	65.16	73.70	71.14	60.54	50.20	40.31	31.71	.....
For the year 1912.....	34.2	37.8	40.9	47.3	56.4	65.5	69.9	68.2	58.2	46.9	40.6	30.7	.....

KILLING FROSTS.

Year.	Last in spring.	First in fall.	Length of frost-free period.
			<i>Days.</i>
1906.....	May 31	Oct. 4	126
1907.....	May 14	Sept. 19	128
1908.....	May 30	Sept. 25	118
1909.....	May 24	Sept. 22	121
1910.....	May 16	Sept. 13	120
1911.....	May 27	Oct. 18	144
1912.....	May 22	Sept. 25	126
Average.....	May 23	Sept. 26	126

CONDITIONS ON THE PROJECT.

During the season of 1912 weather conditions on the project were generally favorable to the growth of crops. Some damage was done to tender vegetables and to orchards by a heavy windstorm on April

29, and a high wind on June 20 resulted in some injury to the sugar-beet crop. The disease known as curly-top, which destroyed a large area of sugar beets in 1911, was absent in 1912, and the yield was good, although the acreage was much smaller than in 1911. The damage to the potato crop by the nematode gallworm was much less extensive than it was the previous year.

The total irrigable area of the 497 farms on the project in 1912 was 54,937 acres, of which an area of 36,620 acres was actually irrigated. The acreage, yields, and farm values of the crops grown in 1912 are stated in Table II. The figures were obtained from the United States Reclamation Service.

TABLE II.—*Acreage, yields, and farm values of crops grown on the Truckee-Carson Project in 1912.*

Crop.	Area.	Unit of yield.	Yield.			Farm value.			
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.	
				Average.	Maximum.			Average.	Maximum.
	<i>Acres.</i>								
Alfalfa hay.....	12,912	Ton.....	33,595	2.60	6.50	\$7.00	\$235,165	\$18.21	\$45.50
Alfalfa and grain hay.....	3,319	do.....	820	.25		7.00	5,740	1.73	
Grain hay.....	284	do.....	319	1.12	4.05	7.00	2,233	7.85	28.35
Wheat.....	2,484	Bushel.....	40,000	16.34	63.33	.90	36,540	14.71	57.00
Barley.....	2,259	do.....	74,792	33.11	70.00	.85	63,573	28.14	58.50
Oats.....	399	do.....	16,875	42.29	125.00	.51	8,606	21.57	63.75
Sugar beets.....	254	Ton.....	2,382	9.38	25.70	5.75	13,697	53.93	147.77
Potatoes.....	483	Bushel.....	65,633	135.89	333.33	.375	24,612	50.96	125.00
Native pasture.....	15,004						60,016	4.00	
Fruit.....	189						2,000	10.58	
Garden.....	150						15,000	100.00	
Miscellaneous.....	135						2,700	20.00	
Less duplications.....	1,252								
Total.....	36,620						469,882		
Average value per acre.....								12.83	

FIELD-CROP EXPERIMENTS.

On account of the great lack of uniformity in the soil of the experiment farm and the presence of harmful quantities of alkali salts, the field-crop experiments have not been extensive. Until the experiments which are being conducted with a view to removing the alkali salts from the soil are successfully applied to the entire farm, the crop experiments will be much limited, both in number and in land area used. There is given below a brief account of the more important field-crop tests conducted in 1912.

SUGAR BEETS.

A fertilizer test with sugar beets was conducted on a clay soil which had not previously grown a cultivated crop. The soil was not uni-

form in texture and it contained some black alkali. It was highly impervious to water, and during the hot months a hard surface crust would form after each irrigation.

The beets were drilled in rows 80 feet long and 18 inches apart and irrigated by furrows in every other row. There were alternately two fertilized rows and four unfertilized or check rows. Of the four check rows only the two middle rows were weighed at harvest time, as it was thought that the rows next to those to which fertilizer had been applied might have been affected by the spread of the fertilizer.

The beets were small and the yields poor, but the results obtained with a few of the combinations of fertilizers were clearly beneficial. Those combinations which resulted in a decided increase in yield were as follows:

Sodium nitrate and potassium sulphate applied at the rate of 290 pounds per acre.

Acid phosphate and potassium sulphate applied at the rate of 290 pounds per acre.

Sodium nitrate, potassium sulphate, and acid phosphate applied at the rate of 540 pounds per acre.

Sodium nitrate, potassium sulphate, acid phosphate, and gypsum applied at the rate of 750 pounds per acre.

EFFECT OF ALFALFA ON SUGAR BEETS.

Several fields on private ranches were surveyed for the purpose of determining the yields of sugar beets on various types of land. The results are shown in Table III.

TABLE III.—*Effect of various types of land on the yields of sugar beets.*

Previous crop.	Kind of soil.	Area.	Yield per acre.	Sugar content.
		<i>Acres.</i>	<i>Tons.</i>	<i>Per cent.</i>
Alfalfa.....	Loam.....	21.3	19.4	18.1
		1.16	25.3	18.0
		4.3	18.9	18.8
None.....	Adobe.....	2.26	3.6	21.8
	Sandy loam.....	2.46	9.9	19.8

These results indicate that a previous growth of alfalfa has a decidedly beneficial effect on the yield of sugar beets.

SWEET CLOVER.

Sweet clover has always been considered as undesirable in many sections of the country, but farmers on the Truckee-Carson Project have come to think well of it. It has been grown for a number of years at the experiment farm, usually on soils where alfalfa would

not grow well. It can be grown successfully on soil containing more black alkali than is tolerated by alfalfa. It has been found that if the crop is cut before blossoming, live stock soon learn to eat it. It has been observed that some horses and cattle eat it as readily as they do alfalfa, while it is apparently disliked at first by others.

It is not recommended that this crop be grown on land that will grow alfalfa successfully, but it may frequently be used on land which for some reason will not produce other crops. The sweet clover may be used as a forage crop to feed live stock or it may be plowed under when several feet high to help bring the soil into better condition.



FIG. 3.—Row tests of alfalfa varieties at the Truckee-Carson Experiment Farm in 1912. Twelve varieties were tested in this manner.

When sweet clover comes up in an alfalfa field it can be killed out the second year, provided the crop is cut during the two years early enough to prevent the clover from producing seed.

ALFALFA.

In April, 1911, 12 varieties of alfalfa were seeded in rows 30 inches apart. (Fig. 3.) The rows were from 320 to 336 feet in length. The entire series was planted in duplicate. The seed of these varieties was furnished by the Office of Forage-Crop Investigations. The results obtained in 1912 are presented in Table IV.

[Cir. 122]

TABLE IV.—*Yields of alfalfa varieties in row tests at the Truckee-Carson Experiment Farm in 1912.*

Variety.	First crop.	Second crop.	Third crop.	Total.	Length of row.	Yield per 100 feet of row.
	Pounds.	Pounds.	Pounds.	Pounds.	Feet.	Pounds.
Caucasus.....	230	135	38	403	320	126
Medicago ruthenica.....	0	0	0	0	322	0
Arabian.....	80	95	82	257	324	79
Peruvian.....	140	140	91	371	325½	114
Grimm.....	215	155	57	427	326½	131
Sand lucern.....	115	115	43	273	327	83, 5
Turkestan.....	185	120	49	354	328	108
Montana.....	185	120	69	374	330½	113
Canadian.....	195	135	59	389	333	117
Western Grown.....	175	145	70	390	334½	117
Provence.....	150	120	53	323	335	96
Elche.....	85	120	62	267	336	79

The Grimm, Caucasus, Western Grown, and Canadian varieties gave the largest yields. The Grimm alfalfa started early in the spring and was ready to cut before any of the other varieties.

MILLET.

Four varieties of millet were grown, namely, the Japanese, Colorado Golden, Hog, and New Siberian. Of these the Japanese yielded the greatest amount of hay, but the Colorado Golden was the earliest and set a large quantity of heavy, plump seeds. The Colorado Golden promises to be valuable on account of its short season and high seed production. Further tests will be made with it for the purpose of ascertaining its seed yield per acre.

FIELD CORN.

A number of varieties of field corn have been tried for several years without obtaining at any time sufficiently large yields to indicate that corn will be a commercially profitable crop in this section, except possibly in the most fertile soils of the old river bottoms. During some years the early dent varieties have a sufficiently long period to mature, but it is probable that for the average season some of the flint varieties will give the highest yields. The Australian White Flint was the earliest and best yielding variety tried in 1912.

HORTICULTURAL WORK.

There are two small orchards on the experiment farm. One of these came into bearing for the first time in 1912. Observations have been made on the bearing orchards on some of the older ranches of the project during the past three years. Identifications have been made of many of the varieties and notes as to their relative productivity have been taken. A few of these old orchards have been

plotted and, so far as possible, the variety name of each tree inserted. The results of the horticultural work have been published separately.¹

TESTS OF VEGETABLES.

For several years variety tests have been made with a number of vegetables. Good results have been obtained with asparagus, beans, table beets, carrots, sweet corn, cucumbers, kohlrabi, melons, onions, peas, potatoes, pumpkins, rutabagas, squashes, tomatoes, and turnips. The results of this work up to and including the season of 1912 have recently been published in detail, together with directions applicable to each crop.²

COOPERATIVE WORK WITH FARMERS.

Since the soil of the experiment farm is not yet in suitable condition for experimental crop work, it has seemed advisable to conduct some of the more urgent crop tests on adjacent older farms, where the soil is better adapted to this work. The greater part of the cooperative work in 1912 was done with potatoes, onions, and strawberries.

POTATOES.

Arrangements were made in 1912 with J. W. Ferguson, Fallon district; W. Vanvoorhis, Stillwater district; Dr. Richards, Island district; and J. W. Rawles, Fernley district, for conducting experiments with fertilizers on potatoes. Seed potatoes from a northern State were used, to avoid danger of introducing eelworms. A variety known as Colorado Pearl, or White Pearl, was purchased from a seed firm in Utah. It was found, after planting, that the germination of this seed was poor, and consequently a poor stand resulted on all the farms, so that at harvest time the fertilizer effect could not be determined.

ONIONS.

A piece of land was selected on the farm of A. R. Merritt as suitable for the onion test. The land had previously been in clover pasture for three years and was manured with well-rotted stable manure during the winter prior to planting.

One hundred and ten rows of onions were planted, with varying quantities and kinds of fertilizers. At the end of the season each row was harvested and weighed separately. It was found that the

¹ U. S. Department of Agriculture, Bureau of Plant Industry, Circular 118, p. 17-28, 1913. Fruit growing on the Truckee-Carson Project, by F. B. Headley and Vincent Fulkerson.

² Bureau of Plant Industry, Circular 110, p. 21-25, 1913. Agriculture on the Truckee-Carson Project: Vegetables for the home garden; and Circular 113, p. 15-22, 1913. Commercial truck crops on the Truckee-Carson Project.

average difference between the yields of unfertilized and fertilized rows was insignificant. The indications are that on rich soil, such as was used in this experiment, commercial fertilizers are of little or no value.

STRAWBERRIES.

In April, 1912, 25 plants each of 20 varieties of strawberries were planted on the farms of W. J. Ferguson, Fallon district; W. Vanvoorhis, Stillwater district; and W. W. Cogswell, Fernley district. As strawberries do not produce a crop until the second year, a report can not be made at the present time on the relative desirability of these varieties.

ALKALI AND GROUND-WATER STUDIES.

Since the establishment of the experiment farm studies have been made to determine the causes of the poor growth made by plants on much of the land, not only on the experiment farm but on numerous other farms on the project. Some very definite results have been obtained and are being prepared for publication.

It has been found that sodium carbonate ("black alkali"), sodium bicarbonate, and sodium chlorid are the alkali salts chiefly affecting the growth of plants. These salts are found in widely varying quantities on different parts of the project, and the proportions in which they are associated are very irregular. Table V states, in percentages, the quantities of sodium carbonate, sodium bicarbonate, sodium chlorid, and other salts found in field S on March 16, 1912, where alfalfa was doing well and also where its growth was not good. This table gives a general idea of the nature and quantities of the alkali salts found on much of the land on the project, but, as before stated, there are wide variations in this feature.

TABLE V.—Percentage of alkali salts determined on March 16, 1912, on an alfalfa plot in field S, Truckee-Carson Experiment Farm.

Depth (inches).	Sodium carbon- ate.		Sodium bicar- bonate.		Sodium chlorid.		Other salts.		Total salts.	
	Good growth.	Poor growth.	Good growth.	Poor growth.	Good growth.	Poor growth.	Good growth.	Poor growth.	Good growth.	Poor growth.
0-8.....	0	-----	0.082	0.027	0	0.003	0.179	0.180	0.261	0.210
8-16.....	0	0.029	.073	.141	0	-----	.082	.305	.155	.475
16-24.....	0	.087	.190	.156	0	.073	.225	.166	.415	.482
24-36.....	0	.095	.098	.370	0	.028	.067	.159	.165	.652

Before successful crop production can be accomplished on lands containing harmful quantities of these salts, methods for reducing the salt content of the soil must be perfected and put into practice.

Much attention has been given to this problem at the experiment farm. Some progress has been made in washing the salts from the surface soil by use of irrigation water after treating the soil with gypsum, but it has been found that before reclamation can be made complete it will be necessary to lower the level of the ground water.

Weekly determinations of the elevation of the water table were made in 19 test wells on the farm during the year 1912. The average depth to ground water was 4.43 feet on April 1, 3.79 feet on June 3, and 4.86 feet on December 27. Salt determinations made on the water in these wells on June 9 showed that the average content of sodium chlorid was 0.868 per cent and that of sodium bicarbonate 0.174 per cent. The water in only seven of the wells contained sodium carbonate ("black alkali") on the same date. The average sodium carbonate content of the water in these seven wells was 0.071 per cent.

It is obvious that successful production of the common field crops will be impossible on this land until the water table is lowered. To attain this end, an electric pumping plant was installed near the southwest corner of the experiment farm in the autumn of 1912 and a tile drainage system was put in at an average depth of $4\frac{1}{2}$ feet. The pumping plant will lift the water collected by this drainage system and discharge it into the surface drain used by the Reclamation Service. It is expected that the use of this system will prevent the rise of the water table each year during the irrigation season and make it possible to continue the work of washing the injurious salts from the surface soil.

FETERITA, A NEW VARIETY OF SORGHUM.¹

By H. N. VINALL, *Assistant Agrostologist, Office of Forage-Crop Investigations,*
and CARLETON R. BALL, *Agronomist, Office of Cereal Investigations.*

HISTORY.

The name "feterita" is used for a variety of sorghum first obtained in 1901 by the Office of Foreign Seed and Plant Introduction as "Feterite" from B. Nathan & Co., Alexandria, Egypt. Only a small quantity of seed was secured, and this was distributed under Seed and Plant Introduction No. 6691 to three persons in Arizona and Kansas, but no records of the results obtained are available. It is certain, however, that the variety did not become established at that time. The second importation, assigned S. P. I. No. 19517, was received November, 1906, from Mr. V. F. Naggiar, of Alexandria, Egypt, who obtained the seed from Sudan. In 1908 an additional supply, S. P. I. No. 22328, was secured through Mr. R. Hewison from Khartum, Sudan, in which region it is commonly grown under the name "feterita." As it is a member of the durra group of sorghums, the name "Sudan durra" has also been applied to it. The value of feterita as compared with the other sorghums of the Sudan is indicated by the following quotation from Schweinfurth:²

Both varieties of the common sorghum, which here abound in all their minor differences of colour, shape, and size of grains, yield well-nigh a dozen different descriptions for the market at Khartoom. The standard of value is fixed by the Fatareetah, a pure white thin-skinned grain, which also is grown by the negroes in the Seriba.

FitzGerald³ also speaks of feterita as the most valuable of the varieties grown by the natives of Sudan. It has been tested for six years at the Chillicothe Forage Field Station and for five years at the Amarillo Cereal Field Station, both in northwestern Texas. It

¹ Issued Apr. 19, 1913.

Much of the material for this publication was collected at Chillicothe, Tex., by Mr. G. E. Thompson, formerly connected with the Office of Forage-Crop Investigations. The publication as now presented was completed by the writers after Mr. Thompson's resignation from the Department of Agriculture.

² Schweinfurth, Georg. *The Heart of Africa*. Tr. by Ellen E. Frewer. New York, 1874, v. 1, p. 245-246.

³ FitzGerald, W. W. A. *Report on the Improvement and Possible Development of the Cultivable Products of the Sudan*, Cairo, 1903, p. 25.

has also been tested during shorter periods at other field stations in the southern Plains area. For the last three years there has been an increasing acreage grown by farmers in that section.

The account of the crop given here is based on the results of these station tests and upon the experiences of farmers.

DESCRIPTION.

Feterita is an early-maturing, drought-escaping sorghum of considerable promise both for grain and forage. It has rather slender stems, varying in height from 4 to 7 feet with locality and season. They are somewhat juicy and very slightly sweet before ripening. Suckers are produced freely when moisture is sufficient and are usually taller and later than the main stalk. The plant also branches freely under favorable conditions, and the branch heads are late in ripening. These habits result in considerable unevenness in maturity.

Feterita resembles milo in habit, except that the heads are uniformly erect and the seeds are larger, softer, and chalk white or slightly bluish white in color. It differs from the ordinary white durra (Jerusalem corn) in having naturally erect heads, black glumes, and plumper seeds. The seed shatters more than milo but less than common white durra if the crop is allowed to stand in the field until overripe.

It is as early or a little earlier than Dwarf milo and two to three weeks earlier than standard Blackbull kafir. In drought resistance it compares favorably with any sorghum yet introduced. In general, the yields have been equal to those of the other grain sorghums and in some cases better, for reasons which are fully discussed later.

PROBABLE VALUE.

From the foregoing description it will be seen that feterita is more like milo than kafir. It resembles milo in earliness, in the size and height of stalk, in the relatively dry pith, the few leaves, the shape of the head, and the large seeds. It differs from milo most sharply in having the heads all naturally erect and in its larger white seeds.

It has become quite popular in parts of northern Texas, because in 1911, a year of severe drought, it produced good grain yields when both milo and kafir gave low yields. In that year much of it was planted on land where the corn crop had been destroyed by drought. In the vicinity of Chillicothe, Tex., many farmers are planting increased areas to feterita in preference to either milo or kafir.

There is no satisfactory evidence that feterita is inherently more drought resistant than other grain sorghums. The Chillicothe re-

sults above referred to may have been due to thinner stands, concerning which no exact data were taken. It often happens that thin stands of feterita are caused by failure of the seed to germinate, especially if planted while the ground is cold. Furthermore, the larger seed of feterita would give thinner stands if planted at the same rate as milo or kafir. At Amarillo, where feterita was grown under identical conditions as to stand, it showed no greater drought resistance than milo or kafir.

Much interest has been aroused also in feterita by the extravagant advertising it has recently received from persons either not competent to determine its merits in comparison with other grain sorghums or from those who had seed to sell at fancy prices.

Experiments so far indicate that its earliness, its rather low water requirements, its satisfactory yields, and the ease with which it may be harvested give it a real place among the sorghums either for grain or combined grain and forage purposes. No farmer should discard milo, Dwarf milo, or Dwarf kafir for feterita, however, until he has determined with certainty that on his farm it will outyield these staple crops when grown under identical conditions. The data at hand are limited, but they do not justify the claim that feterita will outyield Dwarf milo.

PLANTING.

Like other grain sorghums, feterita should be planted in rows 40 to 44 inches apart, or about the same distance as for maize, or Indian corn. The time of planting will vary greatly, but, in general, it should be two to three weeks later than for Indian corn in the same season and locality. In sections affected by the sorghum midge very early plantings are recommended. It is not well to plant too early, while the ground is still cold, since feterita, like other sorghums, is naturally a warm-weather plant. Owing to the soft seed there is liable to be considerable loss through decay before germination unless the soil is warm enough to sprout the seed at once. Difficulty in obtaining a stand has been experienced in some localities, the poor stand probably being due to planting in cold ground.

On the Chillicothe field station, in 1912, plantings of March 19 rotted in the ground, while plantings from the same seed on April 4 and 26 and plantings from a separate lot of seed on May 2 germinated perfectly. At Amarillo a planting on May 11 resulted in a poorer stand and lower yield than plantings on May 22 and 27, about the normal time.

Feterita may be planted either in a furrow with the lister or surface planted with the ordinary corn planter, according to the local custom with related crops. When planted in cultivated rows in this

manner 3 to 5 pounds of seed to the acre will be required. The seed should always be sown in a good, firm seed bed and covered with 1 to 2½ inches of soil.

In only exceptional cases will it pay to sow feterita broadcast for hay. However, if put in with a wheat drill for this purpose 1½ to 2 bushels per acre will give the best results.

CULTIVATION.

Feterita should be cultivated in much the same manner as corn. If the ground is in good shape the harrow will be found the most economical tool for the first two or three cultivations. A thorough and rather deep cultivation should be given when the crop is about 12 inches high. Two later cultivations will be necessary to conserve moisture properly, and in case the ground is foul with weeds still more may be required. In these later cultivations care must be taken that the surface feeding roots are not broken.

In order to save all possible moisture it will be found best to cultivate or harrow after each rain as soon as the ground is dry enough. When the crop has attained such a size that a 2-horse cultivator can not be used, a 1-row, 5-tooth cultivator will be found a very efficient tool. This is also used in many cases to stir the surface quickly after a shower when it would not be practicable to cultivate with a 2-horse plow. When the cultivation is finished the ground should be very nearly level. It does not pay to "ridge the rows," as is often done with corn or milo.

HARVESTING.

For combined use as forage and grain the crop should be cut in the late dough stage. When planted in rows the crop can best be handled with a corn harvester and put in shocks of 20 to 40 bundles each. In sections where there is little danger of rain the shocks may be larger, if desired. If these shocks are allowed to stand for some time before being headed, it will allow more complete maturity of the heads borne on the suckers. When the crop is intended solely for grain it should be allowed to stand until the earliest heads are fully mature, but if left until all the heads on suckers are completely ripe considerable seed may be lost through shattering.

Some follow the practice of cutting the heads from the bundles at the time of shocking by holding the bundles across a chopping block attached to the side of the wagon box. The heads fall inside the wagon box and can be hauled at once to a storage shed preparatory to being thrashed, while the bundles are set up in the field to be used later. If this practice is followed, the grain should be fully mature at the time of cutting. Another method followed with the

grain sorghums where large acreages are grown is to harvest the heads by means of a grain header so remodeled as to place the cutter bar at the proper height.

At lower elevations, when the season is favorable and the seed has been planted early, the first crop can often be harvested with a binder and later a good crop of heads obtained from second growth. In an ordinary year the second growth will furnish abundant pasture even though a second grain crop is not produced.

Where the heads are cut from the standing stalks in the field it is best to pasture the remainder of the crop. Should the crop go down on account of a storm before it is harvested it can be utilized by pasturing with hogs or cattle. Owing to the fact that the head of feterita is quite heavy in proportion to the stalk, the crop sometimes lodges badly in wet weather if left in the field until overripe. This makes it desirable to harvest as soon as the crop is mature.

THRASHING.

Feterita can be thrashed with an ordinary grain separator by decreasing the speed of the cylinder and removing some of the concaves. If a foot or more of stem is left attached to the head, fewer grains will be broken in thrashing.

YIELDS.

The yields of grain obtained during the five years from 1908 to 1912, inclusive, at the Amarillo Cereal Field Station are presented in Table I. For comparison the average yields obtained each year from the various selections of milo and Dwarf milo are also given. In the first four years the yields of feterita are seen to be fairly intermediate between those of the other two crops, being higher than those of milo and lower than those of Dwarf milo. In 1912, feterita slightly exceeded Dwarf milo in grain yield. These results may be taken as fairly representative of what may be expected of feterita on the high plains in comparison with the milos. The considerably thinner stands of the feterita are indicated by the row-space figures.

TABLE I.—*The growing period, row space, and grain yields obtained from feterita at the cereal field station, Amarillo, Tex., 1908 to 1912, inclusive, compared with average similar data for milo and Dwarf milo.*

Year and variety.	Number of plats.	Growing period.	Row space.		Acre yield.	
			To 1 plant.	To 1 stalk.	By plats.	Average.
1908:		<i>Days.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Bushels.</i>	<i>Bushels.</i>
Feterita.....	1	102	10.0	4.4	40.2	40.2
Milo.....	6	105	9.3	5.1	.....	35.6
Dwarf milo.....	5	105	8.6	3.9	.....	4.13
1909:						
Feterita.....	1	99	16.1	10.3	9.3	9.3
Milo.....	14	.....	11.7	6.7	.....	6.1
Dwarf milo.....	10	.....	11.8	7.3	.....	11.0
1910:						
Feterita.....	1	116	37.3	9.3	14.7	14.7
Milo.....	20	109	24.2	8.6	.....	17.6
Dwarf milo.....	17	112	18.8	7.1	.....	19.0
1911:						
Feterita.....	1	102	14.6	5.3	31.9	.....
Feterita.....	1	107	11.5	3.7	35.1	.....
Feterita.....	1	107	10.7	3.5	35.2	.....
Feterita.....	1	107	13.1	3.9	34.5	.....
Average.....		106	12.5	4.1	.....	34.2
Milo.....	10	111	26.2	9.8	.....	30.0
Milo.....	9	111	15.0	5.9	.....	34.8
Dwarf milo.....	15	110	10.7	4.3	.....	37.6
1912:						
Feterita.....	1	122	12.2	4.3	24.5	.....
Feterita.....	1	132	20.9	5.3	21.7	.....
Feterita.....	1	113	32.6	13.5	16.2	.....
Feterita.....	1	116	21.8	5.3	27.3	.....
Feterita.....	1	116	34.8	7.5	24.6	.....
Average.....		120	24.5	7.1	.....	22.9
Milo.....	17	107	7.2	3.5	.....	18.9
Dwarf milo.....	16	107	6.2	3.2	.....	22.6

The yields per acre at the State substation, Lubbock, Tex., for 1912 are as follows:

	Bushels.
Feterita.....	57.71
Blackhull kafir.....	43.96
White milo.....	42.40

The rainfall for Lubbock from January 1 to October 1, 1912, was 11.40 inches, and for the entire year 14.60 inches. Lubbock is situated south of Amarillo on the plains, and the climatic conditions are similar.

At Chillicothe, Tex., in 1912, a plat of feterita gave a yield of 4,800 pounds of dry fodder per acre, while a plat of Dwarf milo planted at the same time made 3,210 pounds per acre. The grain yield on these plats was 30.4 bushels for feterita and 28.4 bushels per acre for the Dwarf milo. These station yields in most cases are not widely different for the two crops, feterita and Dwarf milo, and more data are necessary before definite conclusions are reached regarding their comparative value.

The yields on farms about Chillicothe, Tex., look more favorable for *feterita*. In one case *feterita* planted on June 8, 1911, yielded 22 bushels to the acre. On this same farm, after corn had failed on account of dry weather, the corn land was listed and 1.5 acres of *feterita* planted on July 25. Every stalk produced a mature head, and this field made about 30 bushels per acre. Milo and kafir planted at the same time only partially headed. The rainfall from March 1 to December 1, 1911, was but 14.72 inches, and as the distribution was decidedly unfavorable the season was a severe test on any crop. In 1912 the same farmer planted 8 acres on April 15. A representative acre of this field, topped and thrashed by hand, made a yield of 51 bushels by actual weight.

Headed *feterita* will thrash out about the same percentage of grain as milo or kafir. On the Chillicothe field station one lot of heads, weighing 1,215 pounds, thrashed and cleaned 77.9 per cent, and another lot of 255 pounds thrashed and cleaned 76 per cent of grain.

FEEDING.

The forage value of *feterita* is at least equal to and probably superior to milo. For strictly forage purposes, however, it is excelled by both kafir and the sorghos, or sweet sorghums. The heavy proportion of grain makes it a very efficient feed for horses, cattle, or sheep when used in the bundle. It also makes a good roughage when fed in connection with concentrates for fattening. Like the other sorghums, *feterita* is not particularly efficient as a milk producer. For use as silage, *feterita* will probably be found equal to any other sorghum. The grain itself is undoubtedly comparable to milo or kafir, 10 bushels of it being equal to 9 or more bushels of shelled maize in feeding value. Whether the softer grain of *feterita* is an additional advantage in feeding remains to be determined. The seed coats apparently contain no tannin.

SEED SELECTION.

Home-grown seed is generally more productive than seed brought from a distance. This makes it desirable for every farmer to select and save seed for his own planting. This practice is important with *feterita*, because it is a new crop, somewhat variable and not fully adapted, and also because much natural crossing occurs with other sorghums. Seed selections should be made at a distance of 100 yards or more from other varieties. In all selections care should be taken to avoid hybrids. Exceedingly large heads are generally the result of hybridization or of some local variation in stand or in soil conditions and are not usually desirable. The largest head from the least

row space is what determines the yield. Selections are best made in the field as soon as the first heads mature. Only leafy, erect plants that have no side branches and little tendency to produce suckers should be chosen. The head should be entirely free from the boot, large, and well filled from butt to tip. Such plants, if seeded thickly enough, will produce as much seed as the stooling type and will be much easier to harvest on account of the more uniform maturity of the heads. The field should be rogued consistently each season to remove other types of sorghum if the grain is intended for home planting or for sale as seed.

SUMMARY.

Feterita is a sorghum from the British Egyptian Sudan, in Africa. It is a durra, related to white durra and to milo, with slender stems 4 to 7 feet high under varying conditions, erect heads, and large, rather soft, white grains.

Extravagant claims have been made for feterita by uninformed or interested persons. Experiments show it to be a good grain and forage crop, but not in any way meriting extraordinary praise. It has proved about equal to milo in yield.

All cultural operations are much the same as for milo and kafir, though certain differences are pointed out.

Feterita is newly introduced and quite variable. Therefore seed selection and improvement should be practiced in each district where it is grown in order to obtain adapted strains.

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Issued April 26, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, WILLIAM A. TAYLOR.
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FACTORS AFFECTING THE PRODUCTION OF LONG-STAPLE COTTON.¹

By O. F. Cook, *Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.*

INTRODUCTION.

The Department of Agriculture receives many requests for information and advice regarding the advisability of planting Egyptian and other types of long-staple cotton. The production of long staples has declined for several years because the boll weevil has invaded the former long-staple districts in the lower Mississippi Valley. The resulting scarcity and high prices have stimulated the production of long staples in other parts of the cotton belt, and planters are naturally inquiring how far this readjustment is likely to go.

The question can not be considered as purely agricultural, for the profits of a crop depend upon consumption and selling prices as well as upon the cost of production. More progress has been made in recent years on the agricultural side of the long-staple problem than on the industrial and commercial sides. There is no longer any doubt that the improvement of varieties and of cultural methods will make it possible to produce long-staple cotton more cheaply than in former years and over a much larger area of the cotton belt. In other words, it becomes apparent that the production of long-staple cotton is one of the undeveloped agricultural resources of the United States and one that is capable of enormous expansion. But it is equally apparent that anything like a full development of these resources must be accompanied by extensive changes and readjustments in the commercial and industrial world. Our manufacturers have been accustomed to deplore the limited and uncertain supplies of long-staple cotton. It now remains to be seen how long it will be before they take advantage of the removal of these limitations.

IMPROVED VARIETIES A FACTOR OF THE LONG-STAPLE PROBLEM.

A new factor is introduced into the problem of long-staple production by the early-maturing long-staple varieties that are now being distributed by the Department of Agriculture. The danger that the boll weevil would put an end to the culture of the old late-maturing long-staple varieties was foreseen nearly a decade ago and

investigations were begun to ascertain whether earlier varieties could be obtained. Three such varieties, Columbia, Foster, and Durango, have been developed and introduced to the public. If the necessary precautions are observed, the new varieties can be grown over a large part of the cotton belt. Instead of being excluded by the boll weevil there are reasons to indicate that the presence of this insect may make it more advantageous for the farmer to grow long staples.¹

The time has come for a complete readjustment of opinions that were based on the old late-maturing varieties of long-staple cotton. The new early-maturing varieties can be grown much more widely and the staple can be produced more cheaply. In view of the results secured with the new varieties and the rapidity with which they are now being adopted there is no longer any doubt of the agricultural possibility of establishing a new long-staple industry; but so many factors are involved that no assurance can be given regarding the prospects of long-staple production in the immediate future. Too rapid an expansion of the industry may be expected to reduce prices and destroy profits. Yet these tendencies may be counteracted by increased demands for long-staple fiber. The use of long staples by manufacturers is likely to be stimulated by the prospect of a larger and more regular supply than could have been expected while the old late-maturing varieties were used as the basis of production. There is no possibility of knowing beforehand whether the supply and demand will keep pace with each other. The best that can be done under the circumstances is to point out some of the chief considerations that are likely to affect the long-staple situation in the next few years and leave the farmer to form his own judgment regarding the advisability of planting long-staple cotton in his own district.

PRODUCTIVENESS OF EARLY LONG-STAPLE VARIETIES.

There is a general impression that long-staple varieties are necessarily less productive than short-staple varieties. Many planters have held this idea so long that they now regard it as an absolute principle and find it very difficult to entertain even a doubt on the subject. The impression is based on experience with the old late-maturing small-bolled varieties of long-staple cotton, which required a very long season to ripen a full crop. In reality, there is nothing to show that early long-staple varieties are less productive than short-staple varieties with similar habits of growth.

There is often no advantage in the form of earliness that is represented by the date when the bolls begin to open, for this early opening is a characteristic of short-staple varieties with very small bolls.

¹ Cook, O. F. Cotton improvement under weevil conditions, U. S. Department of Agriculture, Farmers' Bulletin 501, 1912.

The form of earliness that is of practical importance as a means of avoiding weevil injury is represented by the setting of the crop in the shortest period of time after flowering begins.¹ There is no reason to believe that the new long-staple varieties are deficient in this form of earliness. Indeed, they have outyielded short-staple varieties in many experiments.

The fact that the new long-staple varieties are early and productive and can be grown under a wider range of conditions means that planters of these varieties take fewer chances of loss than with the old late-maturing long-staple varieties. Wide fluctuations in the prices made the planting of long-staple varieties more of a speculation than the planting of short staples and tended greatly to discourage long-staple production. Though long-staple planters might in some seasons make more than neighbors who planted short staples there were other seasons when the long staples were much less profitable than the short. But it is difficult to see how the planter of early productive long-staple varieties can be placed at any serious disadvantage with his neighbors. The worst that is likely to happen is not to be able to sell the long-staple crop for what it is really worth in comparison with short-staple cotton.

MARKETING, A COMMUNITY PROBLEM.

The marketing problem has to be solved before the farmer can be assured of the full value of his cotton, whether long staple or short. There is always somebody at hand to buy short cotton at somewhere near regular market prices, but only a few buyers, comparatively speaking, have the skill that is required to deal fairly in long-staple cotton. The average buyer, if he handles long staples at all, is afraid to pay full prices, for fear that his estimate of quality may be wrong. Of the buyers who know the value of the cotton, many do not feel called upon to inform the farmer, it being their idea of business to buy as cheaply as possible. The greater difficulty of marketing long-staple cotton to a proper advantage is one of the reasons why growers have been advised to organize themselves on a community basis.²

SPECIAL REQUIREMENTS OF LONG-STAPLE PRODUCTION.

With early long-staple varieties as productive and as easy to grow as short-staple varieties there might appear to be no reason why higher prices should be paid for long staples than for short. But if the buyers or manufacturers were to act on this assumption they would defeat their own interests. The intrinsic value of the long

¹ Cook, O. F. Relation of drought to weevil resistance in cotton, U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 220, 1911.

² Cook, O. F. Cotton improvement on a community basis. Yearbook, U. S. Department of Agriculture, for 1911, p. 397-410.

staple is higher because finer, stronger, and more durable articles can be made from the long staples than from short. The farmer should receive his share of the advantage, even if it were as easy to maintain the production of long staples as of short staples. But in reality this is far from being the case. Long-staple cotton requires not only more favorable natural conditions but greater intelligence and skill on the part of the farmer. If the ability needed in this branch of agriculture is not properly remunerated it will not be enlisted.

If a new long-staple industry is established, it must be on a very different basis from the present short-staple industry. The results for the first season or two with a new variety in a new district are likely to be entirely deceptive. Unless special attention is given to the problem of maintaining stocks of pure seed by continued selection, the crop is sure to decline in quality as well as in quantity. With the usual neglect of selection, crossing of varieties in the field, and admixture of seed at public gins, the uniformity of an improved stock is usually lost before it has been out of the breeder's hands for more than two or three years. Degeneration becomes apparent in long-staple varieties sooner than in short staples, because the requirement of uniformity is higher. Spinners can not use mixtures of long and short cotton, so that bales representing a mixture of long and short varieties have less value than the same amount of short cotton alone. It is a mistake to suppose that a successful long-staple industry can be maintained by the ordinary methods of cotton farming.

As yet there are very few farmers who appreciate the importance of preventing admixture of seed of different varieties at the gin or crossing in the field. While improvements in this direction may be expected, the change is likely to be very gradual and to become effective only in communities that specialize on the production of a single superior variety of cotton. If the uniformity of superior stocks is preserved, the seed can usually be sold at a higher price, as well as the fiber. Community organization is as necessary for maintaining pure stocks of seed as for marketing the crop to best advantage. Any effective encouragement of long-staple production by commercial or manufacturing interests is likely to come about through cooperation with organized communities of farmers who will limit themselves to a single superior variety of cotton. Desultory plantings of long staples by scattered individual farmers are likely to produce only a precarious supply, irregular alike in quality and quantity. Improved methods have been developed which simplify the work of selection and render it more effective, but all such work must have a basis of thorough familiarity with the variety.¹

¹ Cook, O. F. Cotton selection on the farm by the characters of the stalks, leaves, and bolls. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 66, 1910.

PREMIUMS FOR LONG-STAPLE COTTON.

Notwithstanding their greater utility the new early-maturing long-staple varieties can not be expected to place the long-staple industry on the same basis as the short-staple industry, and this would not be desirable. The greater care that is necessary in maintaining long-staple varieties, as well as in growing, handling, and marketing the crop, must be compensated by a higher price for the product or the precautions will not be observed. The more careful and intelligent planters will not continue the cultivation of long-staple cotton and permanent long-staple communities will not be established.

Nevertheless, the difference in prices between long and short staples need not be as large as was necessary formerly, when only the old late-maturing varieties were available. Figures furnished by an association of New England manufacturers, covering a period of years, showed that the cost of their supplies of long-staple cotton had been about 60 per cent higher than the prices paid for corresponding grades of short staples. With the earlier and more productive long-staple varieties that are now available, smaller premiums, perhaps not more than 30 per cent on the average, may be sufficient to develop and maintain a long-staple industry. No doubt the actual prices will continue to fluctuate with the seasons in accordance with the general relations of supply and demand, but unless a fair average is maintained the industry will not attract the participation of the best class of farmers.

PROSPECTS OF LARGER DEMANDS FOR LONG STAPLES.

If the commercial conditions that determine the demand for long-staple cotton remain the same in the future as in the past only a limited utilization of the new varieties is to be expected. With a strictly limited demand a condition of overproduction must be soon reached, prices will decline, farmers will be disappointed, and many of them will go back to short-staple varieties. But in reality the demand for long staples is not strictly limited. It is rather the limited and uncertain supply that has restricted the use of long staples. There is every reason to expect a greatly increased consumption if long staples can be supplied more regularly and cheaply, and this is made possible by the new early-maturing varieties. Of course, too rapid expansion of long-staple production may cause a slump in prices, but a cheap and abundant supply would have the indirect advantage of encouraging use and thus tending to establish a larger permanent demand.

Increased demands for long staples are to be expected on account of their industrial superiority over short staples. Short-staple cotton is only poorly adapted for many of the purposes for which it is now

used. Improvements in machinery have made it possible to spin shorter and shorter fibers, but the resulting fabrics are weaker and less durable. From a general economic standpoint a large part of the labor expended in producing inferior cotton and manufacturing inferior fabrics appears to be wasted, to say nothing of the loss imposed on the consuming public.

In view of the great amount of attention that the problem of the increased cost of living is now receiving in all quarters it does not seem reasonable to believe that the immense economic waste involved in the production and manufacture of inferior cotton will be left out of consideration much longer. Some of the States have laws to protect the public against textile adulterations as well as against adulterations of food, and the various suggestions for pure-clothes laws are rapidly taking more definite form. There is even more reason why the public should protect itself against inferior fiber in cotton fabrics than against cotton mixed with wool or silk, where the deception is much more easily detected.

While there are many legitimate uses for short, inferior fiber, there are also many illegitimate uses, that is, uses not to the advantage of the consuming public, however profitable they may be to the manufacturer and dealer. In the presence of productive, early-maturing long-staple varieties there is no longer any valid agricultural reason for this wasteful substitution of inferior short staples for industrial purposes that would be better served by the use of long staples. But the mechanical and commercial reasons remain, and these will continue effective as long as profits can be made from the manufacture and sale of weak, short-lived fabrics to an indiscriminating public.

When the importance of these factors is once appreciated, remedial measures are not likely to be delayed very long. A large measure of protection would be obtained by a simple requirement that the public be informed regarding the length of the fiber used in textile articles. A regulation of this kind would be easy of enforcement, for the length of cotton fibers is readily determined with improved appliances that are now available. Even though no standard of strength were prescribed, the danger of deception on this side would be relatively small, for manufacturers would hardly find it worth while to make a specialty of collecting supplies of weak long-staple fiber, which would also be more difficult to spin and weave into fine, well-finished fabrics.

With any approximation to equality in the cost of production the long staples can compete readily with the short staples. The short staples have been used because there seemed to be no prospect of securing adequate and regular supplies of long staples and in spite of the well-known inferiority of the short staples. But now the question is to change back toward the use of long staples. The

difficulties and uncertainties of the present situation lie in the readjustments that must be made in placing the cotton industry on a more honest and substantial basis, and thus open the way to a better development of our resources of production. The competition that is rapidly springing up in many foreign countries is likely to force these changes in time, if they are not accomplished voluntarily in the interest of American agriculture and of our own consuming public.

CONCLUSIONS.

The improved varieties of long-staple Upland cotton developed and distributed by the Department of Agriculture introduce a new factor into the problem of production. On account of their early-maturing habits these long-staple varieties often yield as much as short-staple varieties, and they are adapted to cultivation in many parts of the cotton belt where the old late-maturing varieties could not be grown to advantage.

Too rapid adoption of the new varieties will result, no doubt, in overproduction and a decline in prices of long staples. But, on the other hand, there is reason to expect a large increase in the demand for long staples, which are better adapted to many industrial purposes than the short staples that are now being used. The prospect of a larger and more regular supply of long-staple cotton is likely to lead to more extensive use and tend to more stable commercial conditions, thus permitting a gradual development of the new long-staple industry.

BEHAVIOR OF SEED COTTON IN FARM STORAGE.¹

By CHARLES J. BRAND, *Physiologist in Charge*, and W. A. SHERMAN, *Scientific Assistant, Farmers' Cooperative Cotton Handling and Marketing.*

INTRODUCTION.

The question of storing or bulking cotton in the seed for a time before ginning is one in which considerable interest has developed. Ginners, spinners in the cotton belt, and others have claimed that many desirable results would follow from a general practice of storing seed cotton for a period of two to five weeks before ginning. They have also emphasized the probable benefits of "sweating out" and aging, and called attention to savings that might result, such as reduction in loss of time of men and teams from standing at the gin awaiting their turn, increased output of lint per gin stand, and many other benefits. Apparently very few definite experiments along this line have been conducted, and, so far as the writers know, none have been described either in the cotton journals or in the publications of agricultural colleges and experiment stations.

In order to determine somewhat accurately the behavior of unginned cotton picked at various times and under varying conditions, a cooperative arrangement was made with Mr. E. W. Evans, of Bennettsville, S. C., during the picking season of 1912.² Mr. Evans had slightly reconstructed one of his farm buildings for use in aging or storing his staple cotton prior to ginning. The dimensions of this buildings are 30 by 60 feet, and the ground floor had been divided by complete partitions into four compartments or bins, each 15 by 30 feet. The arrangement of these bins can be seen in figure 1.

The well-floored loft above the storage bins was left without partitions of any kind and the cotton pickings of each day were placed in the loft, spread generally over the floor to an average depth of 18 inches. The purpose of this procedure was to give the various pickings an opportunity to dry out to a moderate degree before they were finally bulked and forked through the trapdoor into one of the bins below. The building has a double wall, being sided with ordinary

¹ Issued Apr. 26, 1913.

² All temperature and moisture observations were made by Mr. Chester A. Kotterman, formerly laboratory aid in the Office of Farmers' Cooperative Cotton Handling and Marketing, who was stationed at Bennettsville, S. C., during the greater part of the cotton-picking season.

weatherboarding and lined with matched lumber. The inner partitions were also of matched material, but of one thickness only.

A ventilator about 2 feet long by 10 inches in width, covered with fine wire screen, was placed in the outer wall of the building next to the ceiling of each bin, and the communicating doorways between bins were kept open most of the time, thus affording a limited circulation of air above the stored cotton.

On September 30, when the final arrangements for the work had been completed, bin A contained a fairly large bulk of seed cotton weighing about 10,000 pounds, composed of early pickings. On October 1 this cotton was removed to bin B, and the first lot of cotton to be used throughout the storage season was forked from the loft into bin A below. Arrangements were immediately made for placing this bulk on a definite floor space, burying in it at selected depths and in different parts 10 electrical thermometer bulbs with leads of suitable length for attaching in the aisle outside to a regular balance indicator with galvanometer. This cotton had been picked on September 25 and had remained in the loft one week. It weighed 5,800 pounds and when thoroughly tramped had a density of about 12.3 pounds per cubic foot in the pile. The average depth of the cotton as finally left for the experiment was 3.5 feet. This body of cotton is designated as pile 1 in figure 1.

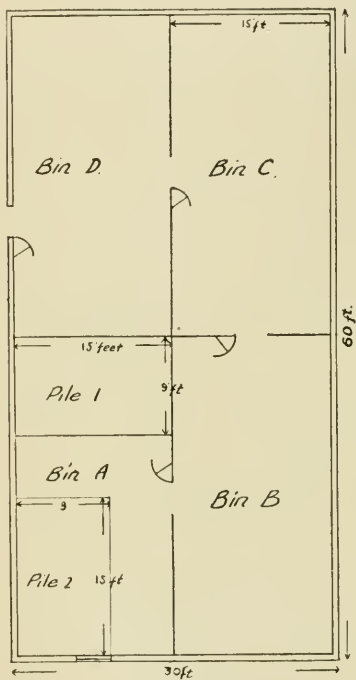


FIG. 1.—Floor plan of storage house, showing the size and location of bins and the space occupied by the cotton under observation.

On October 2, for purposes of comparison, a freshly picked lot of cotton weighing 6,180 pounds was placed in bin A, shown in figure 1 as pile 2, to be used in comparing the behavior of freshly picked cotton without a preliminary loft drying with cotton that had been allowed a week in which to dry out. The second lot of cotton was left without tramping and made a pile of an average depth of 4.5 feet, having been so placed as to occupy the same number of square feet of floor space as pile 1. This pile of cotton had a density per cubic foot of 10.1 pounds and represented the pickings of October 2 which had been left out in the warm sun throughout the day and then placed in the bin in the evening directly after being

weighed. The appearance of these piles of cotton is shown in figure 2. The mass at the left is the untramped cotton. The tramped pile is shown in part at the back. The leads from the thermometer bulbs may be seen here and there on the face of the cotton.

TEMPERATURE IN UNGINNED COTTON STORED UNDER VARYING CONDITIONS.

The records of temperature shown in Table I apply to both piles of cotton, the tramped and the untramped. The bulb buried in pile 1 at point 1 compares most directly with the one buried in pile 2 at



FIG. 2.—Two piles of experimental cotton in bin A. The one at the left has not been compacted in any way; the other was thoroughly tramped.

1', 2 with 2', and 3 with 3'. All were buried about midway of the total depth of the respective lots of cotton, well removed from immediate effects of room and outside temperatures and humidities. The conditions that prevailed in the middle of each pile are represented by 2 and 2'.

The temperatures and humidities from October 5 to November 17, shown in the table, are the average of three daily observations taken at 7 a. m., 12.30 p. m., and 6 p. m.

[Cir. 123]

TABLE I.—Average daily temperatures in tramped and untramped seed cotton and average daily temperature (°F.) and relative humidity outdoors and in storage bin, October 5 to November 17, 1912.

Date (1912).	Temperature (° F.) in tramped (1, 2, 3) and untramped (1', 2', 3') piles.						Outside.		Inside.	
	First bulb pair.		Second bulb pair.		Third bulb pair.		Temperature.	Relative humidity.	Temperature.	Relative humidity.
	1	1'	2	2'	3	3'				
October—										
5.....	69.3	83.1	69	82.8	68.5	80.4	76	55	75	58
6.....	69.4	81.5	69.8	81.3	68.8	79.3	74	50	76	44
7.....	70.7	78.6	70.8	79.9	70.9	77.9	76	44	74	58
8.....	70.8	72.8	71.3	79.3	71.3	77.9	69	63	69	63
9.....	71.7	67.6	71.9	77.7	70.6	75.6	65	61	66	53
10.....	71.3	68.5	71.7	76.8	70.3	73.6	71	68	71	72
11.....	72.7	72	72.2	76.4	71.3	73.9	74	74	75	74
12.....	73	72.3	72.6	75.9	72.3	74.5	75	70	74	74
13.....	73.9	73.2	73.7	74.7	72.8	74.1	75	74	75	78
14.....	74.5	69.2	74.8	75.9	73.5	73.9	57	82	57	88
15.....	74.6	64.5	74.6	74.2	71.7	71.8	63	69	63	69
16.....	73.8	62.8	73.8	73.3	70.5	70.7	60	63	60	63
17.....	72.5	60.4	72.2	71.6	68.8	68.7	57	71	57	66
18.....	70.9	60.6	70.9	70.1	66.4	67.4	63	79	63	74
19.....	69.9	65.3	70.4	68.9	66.8	66.8	68	90	68	90
20.....	70.2	67.6	70.3	69	67.6	67.4	66	71	66	71
21.....	70.2	64.2	70.3	69.2	67.7	67.1	60	89	61	89
22.....	70.1	66	70.1	68.1	67.6	66.3	68	95	69	90
23.....	69.5	67.3	70.1	68.3	67.6	67.2	65	66	65	70
24.....	69.7	58.8	70.2	67.9	67.3	65.8	53	52	53	63
25.....	67.6	55.5	67.8	66.6	65	64.2	57	45	55	65
26.....	66	56.7	66.7	65.5	63.5	63.2	57	61	57	61
27.....	65.5	55.6	66	64.9	62.8	62.5	57	50	58	46
28.....	63.7	53.7	64.7	64	61.3	61.4	54	53	53	58
29.....	62.8	55.1	63.2	62.5	60	60.4	57	61	56	55
30.....	61.5	57.1	62	61.9	60	60.2	62	69	63	69
31.....	61.2	59.6	61.9	61.3	60.3	60.6	61	68	63	69
November—										
1.....	61.8	63.1	62.8	61.7	61.4	61.5	68	90	68	85
2.....	62.8	60.4	62.6	62.1	62.3	62.1	50	55	53	58
3.....	62.3	50.3	62.8	61.3	59.8	59.6	42	62	43	55
4.....	60	46.7	61.3	58.8	57	57.1	47	53	46	58
5.....	58.9	48.8	59	57.6	56.1	55.9	51	56	52	63
6.....	57	57.6	57.9	57.3	56.6	56.1	65	85	65	85
7.....	58.3	65	58.5	58.8	58.5	58.7	68	90	69	81
8.....	59.9	61.6	59.9	59	60.6	60	57	61	59	62
9.....	60.7	58.5	61.1	59.1	59.4	60	46	65	49	61
10.....	60.3	53.8	60.4	58.4	58.9	58.1	49	61	51	56
11.....	59.6	52.6	59.6	57.4	58.5	57.4	53	58	53	58
12.....	58.9	55.9	58.9	59.9	58.3	57.9	58	61	59	62
13.....	59.6	60.9	59.6	58.4	59.4	59	62	74	64	74
14.....	59.8	59.4	59.8	59	60.4	60.1	60	68	63	64
15.....	60.3	53.1	60.3	57.6	60.5	58.1	42	47	46	65
16.....	59.8	48.6	59.8	57.3	57.6	56.7	42	62	43	63
17.....	57.8	45.9	57.8	55.5	54.9	54.5	35	72	39	67

The fluctuations in temperature in both tramped and untramped cotton were so slight that it is evident that practically no heating took place. Bulbs 1, 2, and 3 were in tramped cotton, pile 1. Bulb 1 reached its maximum temperature, 74.6° F., on October 15, 10 days after the cotton was placed in the pile, a rise of only 5.3 degrees. From this date there was a gradual subsidence except during the last 10 days, when there were slight fluctuations, the total decline amount-

ing to about 15 degrees from the maximum. The course of bulb 2 very closely agrees with that of bulb 1, while bulb 3 averages slightly lower throughout.

Bulbs 1', 2', and 3' occupied nearly corresponding positions in the untramped cotton, pile 2. Each of these started in with a higher temperature than the other pile developed at any time. It should be remembered that the cotton in pile 1 had been spread in the loft a week, while pile 2 was composed of cotton brought directly from the field, which had retained considerable warmth received directly from the sun. This accounts for the high initial temperatures in the second pile. These bulbs showed a fairly uniform decline, except in the case of bulb 1', where there was a rise of 10 degrees from October 28 to November 1, followed by a decline of over 16 degrees to November 4 and another rise of 18 degrees by November 7. This bulb was located in the most compact part of the loose pile, and the fluctuations may be due to slight heating in spots, because sheets containing cotton picked in the morning carried more moisture than those picked in the afternoon. Correspondingly sharp changes were not noted in the temperatures recorded from bulbs 2' and 3'. A bulb giving readings not shown in the table placed on the floor under the center of pile 1 agreed closely with the outdoor temperature. This indicates that such temperatures as were developed were not communicated downward in such a way as to affect the layer of cotton immediately on the floor. The building is on blocks, allowing free circulation of air under it.

The temperatures outside and inside the building show no marked difference in fluctuations and no correlation with temperatures generated within any of the piles. The same may be said regarding the relative humidities, which have been included chiefly because of their interest as showing the atmospheric moisture conditions that prevailed during a large part of a single cotton-picking season.

MOISTURE CONDITIONS IN UNGINNED COTTON IN FARM STORAGE.

On October 1, when possession was taken of bin A, the cotton then in it was moved to bin B (fig. 1). On October 15 this cotton was moved again to bin C. Two thermometer bulbs had been placed in the pile when it reached bin B. The temperatures indicated by these gradually rose from October 1 to October 15. On the first date these bulbs, which were buried in the pile at different places, but both 18 inches deep, showed temperatures of 69° and 70° F., respectively; on October 7, 74° and 72° F.; and on October 14, 82° and 80° F. On October 15 the still rising temperature was interrupted by forking into bin C.

On October 10 samples were taken at four points in this pile of cotton for the determination of moisture. Two of these were drawn

from the cotton around the bulbs, which were 5 feet apart, and two from other places in the inner part of the pile. The variation in moisture content was found to be inconsiderable, the four points sampled showing the following percentages: 14.04, 14.88, 14.71, and 14.46.

To avoid loss of moisture, tightly covered tins, such as are used in making soil-moisture determinations, were employed for taking samples, and the moisture was determined immediately. A small type of single-wall, heavy copper drying oven was used in this work.

On October 15 the cotton in this pile was sampled again, two composite samples being taken from the deeper portions and two composite samples from the outside of the pile. The former showed a moisture content of 14.72 and 14.38 per cent, respectively, while the two from the outside contained 11.88 and 11.07 per cent. These figures indicate that there is a fairly uniform diffusion of moisture through a large body of cotton. It will be remembered that this bulk contained about 10,000 pounds.

At the time of sampling, on October 15, the cotton inside the pile felt warm to the touch. On October 1, before this cotton had been moved from bin A to bin B, thermometer bulbs that had been buried in it showed temperatures as high as 111° F. in spots. When moved to bin B it cooled off considerably, but remained between 70° and 80° F. That the moisture conditions in these lots of cotton were not unusual is shown by a comparison with the conditions that prevailed in piles 1 and 2 in bin A. On October 8 the surface cotton in both of these piles showed a moisture content of 11.95 per cent, there being no difference between the tramped and untramped cotton. The cotton at the center of the pile showed a moisture content of 14.45 per cent for the tramped cotton and 14.06 per cent for the untramped cotton.

On November 25 moisture determinations were made again on piles 1 and 2, which had then been in storage for nearly seven weeks, the former having passed through a week of preliminary drying, while the latter was placed directly in the storage bin. The surface cotton of the tramped pile contained 9.1 per cent of moisture, while the surface cotton of the untramped pile contained 9.4 per cent. The deeper cotton within the tramped pile had a moisture content of 13.7 per cent, while that similarly located within the untramped pile had 12.05 per cent, possibly indicating the more ready loss of moisture from the looser cotton, which would be expected.

Moisture determinations were made again on this cotton on the day when it was ginned. Both the surface and interior cotton of the untramped lot had lost more moisture than the tramped lot. The interior cotton of the latter maintained a moisture content of 13.4

per cent, while the interior of the looser and untramped contained 10 per cent. The surface cotton of the two piles by this date, December 1, had run down to 8.7 per cent on the tramped and 8.8 per cent of moisture on the untramped pile. As far as can be observed, there were no correlations between moisture and temperature in these two lots of cotton.

A bale of the staple, which is about $1\frac{1}{4}$ inches long, from the tramped pile was purchased for spinning and waste comparisons with freshly picked and immediately ginned cotton of the same variety, namely, Webber, and with another bale ginned from a body of 40,000 pounds of seed cotton of the same variety which had been stored unginned for a considerable period in bin C.

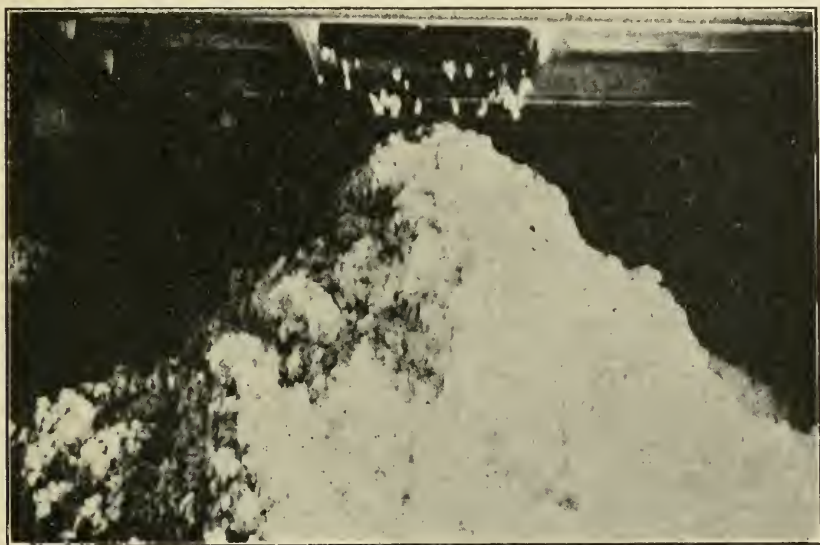


FIG. 3.—Pile containing about 30,000 pounds of seed cotton. This cotton was picked through a period of several weeks and did not suffer from heating.

Bins C and D ultimately contained between 70,000 and 80,000 pounds of seed cotton. This was accumulated gradually, the cotton at the bottom having received the preliminary drying in the loft, while the later pickings were added to the pile daily, unless rains occurred which made it advisable to dry the early morning pickings of certain days before adding them to the pile. It was found that practically all of the later pickings, if dry when picked, could be thrown into the bulk without any danger of heating.

About the middle of November, when the pile in bin C had attained a weight of about 30,000 pounds, two composite samples were taken from both the inside and the outside of the pile. The pile of cotton as it appeared at this time is shown in figure 3.

The moisture content of the surface cotton was 10.86 per cent in one sample and 10.4 per cent in the other, while the two inner samples showed a moisture content of 10.26 and 10.85 per cent, respectively. It is not surprising that this lack of variation in moisture between the surface and the deeper cotton should occur, as compared with the other piles in which moisture determinations were made. The pile was built up gradually. The warm, dry cotton which had remained in the sun each day until evening in the pickers' sheets had had ample opportunity to dry out and went to the storage house in this condition.

THE EFFECT ON SEED GERMINATION OF TEMPERATURES DEVELOPED DURING STORAGE.

The germination of cotton seed is proverbially poor under the usual conditions of handling and storage, and this accounts in a large measure for the habitual use of about four times the quantity of seed needed for a stand. In the days when most of the surplus was composted for manure on the plantation, it was well understood that only a little fermentation and heating need take place to prevent any trouble from the germination of the seed so used.

Our temperature observations at Bennettsville afforded opportunity for only a partial confirmation of this belief, but germination tests on seed from three lots having different temperature records were made by the Seed Laboratory of the Bureau of Plant Industry, as follows:

The first was from a composite sample of seed cotton taken from the surface of pile 1 in bin A, previously described, about a week after picking, the cotton having been spread on a loft floor meantime and subjected to no heating nor to any effect resulting from bulking. The weather from the time of the opening of the first bolls until picking had not been such as to cause any evident damage, and the weather during the last week in September when the cotton was picked was dry and in every way favorable. The sample was kept in a perfectly dry room, brought to Washington at the close of the Bennettsville work, and several hundred seeds were hand ginned for the test. The first test showed a germination of 43.5 per cent in seven days; a retest showed 64 per cent. There was some anthracnose in evidence in this field, but so far as known no other apparent reason for the low percentage of germination.

The second test was of seed taken from an earlier picking from the same field, there being about 10,000 pounds of seed cotton in the mass. This had been stored in a room 15 by 30 feet. It had been forked over from the center and the sides and from end to end of the room three times and the whole mass had been moved once from one room to another.

When our observations began, bulbs were planted in almost every part of the pile, which was at no point more than 4 feet deep, and temperatures were found ranging from 69° to 111° , with the room temperature at 65° F. A sample was drawn from the immediate vicinity of the bulb registering 111° F. and was thereafter kept in a small sack in a dry place until the seeds were picked from it by hand for the germination test. Two tests of this seed showed a germination of 13 and 5 per cent, respectively.

On October 7 the Southern Cotton Oil Co.'s mill at Bennettsville was shoveling over a pile of about 100 tons of seed the previous history of which is unknown, but it was a little above blood heat in several spots at the time. This seed was rebulked in the seed house, and two bulbs were planted in the mass as it was moved and then covered with some 10 tons of seed. The first record of temperature made on October 9 showed 87.25° and 82.5° F. for the two bulbs. On October 11 the readings were 89° and 86.5° , respectively; on October 21, 127° and 133° F.

The manager of the oil mill considered the seed in a dangerous condition at this heat and immediately began its manufacture. More frequent observations were not made, because the oil mill was located at a considerable distance from the storage house, which made daily records at both places impracticable. On October 21 a sample of seed was drawn from the portion of the pile registering 133° F. Two tests have been made without germinating a single seed from this lot.

The most important results of these tests are those developed from sample 2. This cotton had not apparently been injured in any way by the heating to which it had been subjected; it had not been wet when picked or when stored. It contained, of course, a larger proportion of freshly opened bolls and a smaller proportion of thoroughly dried-out bolls than the cotton which was picked a week later. Its behavior was entirely different, and though it was closely watched and an unusual amount of labor expended in frequently forking it over and stirring it about, yet the planting value of its seed was practically destroyed at certain points in the mass within the first 10 days of storage. Our tests of freshly picked samples of this same cotton showed from 43 to 64 per cent of germination. Whether a cotton of stronger germinating power would have withstood the same degree of heating in storage with less damage is an open question.

The practical point to be observed is that cotton from which planting seed is to be saved must be so thoroughly dried out before bulking or must be spread out in such thin layers as to prevent any noticeable development of heat if the germination of the seed is not to be affected. These observations have not covered a suffi-

ciently wide range of conditions to enable us to establish any definite degree of temperature at which germination begins to suffer, but the observations made indicate very clearly that it is not safe to plant any seed which has been subjected to even the slightest heating and fermentation, and that the planting value of the seed may be entirely destroyed by a sweating and curing-out process, which does not injure the lint to any perceptible extent. The practice of saving seed for planting from late pickings is due, no doubt, to the greater tendency of early pickings to heat.

When this particular pile of cotton was forked over to bin B, on the morning when the maximum temperature of 111° F. was discovered, it was thoroughly mixed and no portion of the pile again developed a temperature of as much as 90° F. This would indicate that the heating which had reduced germination to about 10 per cent was only a transient condition incident to the curing of the pile.

CONCLUSIONS.

As a result of this season's observations the conclusion is reached that similar data must be secured on earlier pickings and on cotton picked more promptly after rains, as well as upon cotton stored in larger and smaller piles and in both moist and dry climates, before any definite rules can be laid down concerning temperatures at which injury to seed or fiber takes place. An interesting question arises as to the effect on the milling and feeding value of seed which has been so heated as to prevent germination. Experiments and observations on a number of these points are planned for the coming season. The facts here recorded are believed to be of value as establishing certain known points of damage to germination, and also as showing the perfect safety with which considerable bodies of mature seed cotton can be stored if care is taken to have the cotton free from exterior moisture when stored.

EGYPTIAN COTTON CULTURE IN THE SOUTHWEST.¹

By CARL S. SCOFIELD, *Agriculturist in Charge of Western Irrigation Agriculture.*

INTRODUCTION.

Since 1902 the Bureau of Plant Industry has been experimenting with Egyptian cotton in the irrigated sections of the Southwest. At the close of the season of 1911 these experiments had reached a stage which seemed to justify the trial of this crop on a small scale by farmers in the Salt River Valley in Arizona and in Imperial County, Cal.

In the spring of 1912 a supply of seed was distributed by the Department of Agriculture for planting by a number of farmers. Most of the seed so distributed was of the Yuma variety, a new type developed in Arizona as a result of careful selection which had been carried on for several seasons. The investigations and experiments made in connection with the breeding and acclimatization have been reported in numerous publications of the Bureau of Plant Industry. The seed distributed in 1912 was entirely free from contamination with the degenerate type known as Hindi cotton, which infests practically all of the cotton grown in Egypt. This seed was distributed to about 75 farmers, and about 530 acres were planted in the spring of 1912. The location of these farmers and the acreage in each locality were as follows: In the Salt River Valley, 32 farmers planted 303 acres, besides 29.5 acres planted on the Indian reservations; in the Colorado River Valley north of Yuma, Ariz. (vicinity of Bard, Cal.), 19 farmers planted 44 acres; in the Imperial Valley, Cal., 25 farmers planted 122 acres. In addition to this acreage in the Imperial Valley, there were 20 boys who planted one-half acre each under the direction of Mr. Walter E. Packard, of the California Agricultural Experiment Station, cooperating with the Bureau of Plant Industry. Near Hechicera, Mexico, south of the Imperial Valley, there was one field of 30 acres.

¹ Issued Apr. 26, 1913.

The work of the Bureau of Plant Industry in connection with establishing the Egyptian cotton industry in the Southwest is conducted under the direction of a committee composed of Messrs. C. S. Scofield, C. J. Brand, O. F. Cook, T. H. Kearney, and W. T. Swingle.

These experimental plantings by farmers were made under the supervision of Mr. Argyle McLachlan and Mr. E. W. Hudson, both of the Bureau of Plant Industry, Mr. Hudson devoting his attention chiefly to the work in the Salt River Valley.

ACREAGE AND YIELDS.

Owing to various causes, a portion of the acreage planted to Egyptian cotton failed to produce a crop. Among these causes was the lack of irrigation water for some of the fields, while the soil in other fields was too salty, and in one section high ground water, resulting from a flood in the Colorado River, killed the crop in mid-summer. About 480 acres came through the season to harvest. From this acreage 375 bales of about 500 pounds each were finally picked and ginned. Of the total number of bales 262 were ginned in the Salt River Valley, 17 in the vicinity of Bard, Cal., and 96 in the Imperial Valley. These figures do not include 24 bales produced on the experiment farms at Sacaton, Ariz., and Bard, Cal.

The yields from different fields varied greatly. Many of the farmers who planted cotton were not familiar with the requirements of the crop, and some fields were given very little attention after planting. The average yield of lint per acre, determined from the total quantity of lint known to have been picked and baled and the total number of acres upon which this cotton was produced, was approximately 400 pounds. The acreage upon which this computation is based included, however, much land on which the crop was very light.

A number of fields were measured during the season, and records were kept of the crop harvested. The yields determined from fields in the Salt River Valley are given in Table I.

TABLE I.—*Yields of ginned cotton from certain measured fields of Egyptian cotton grown by farmers in the Salt River Valley in 1912.*

Size of field.	Yield of fiber.	
	Total.	Average per acre.
<i>Acres.</i>	<i>Pounds.</i>	<i>Pounds.</i>
3.38	2,527	747
5.32	3,872	729
5.35	3,818	714
1.42	994	700
4.75	3,245	683
15.25	10,180	667
10.35	5,937	573
2.89	1,461	506
1.62	794	490
13.45	6,558	488

The yields of cotton shown in Table I vary from slightly less than 1 bale per acre to nearly 1½ bales per acre. While these yields were

much above the average for the entire acreage devoted to the crop, they are sufficient in number to indicate what may be expected by the better farmers on rich land which had previously produced alfalfa, as was the case with most of the yields reported upon.

Two of the yields reported in Table I were those obtained by Pima Indian farmers on the Sacaton Reservation. One of these Indians made a crop of 994 pounds and the other 794 pounds from their fields of about $1\frac{1}{2}$ acres each.

TABLE II.—*Yields of ginned cotton from certain measured fields of Egyptian cotton grown by farmers in the Imperial Valley, Cal., in 1912.*

Size of field.	Yield of fiber.	
	Total.	Average per acre.
<i>Acres.</i>	<i>Pounds.</i>	<i>Pounds.</i>
11.00	6,105	555
4.76	2,537	533
1.32	620	470
5.00	2,000	400
5.09	2,015	396

The yields from fields in the Imperial Valley as shown in Table II range much lower than those from the Salt River Valley reported in Table I. The lower yields were due chiefly to the less careful preparation of the land and handling of the crop by farmers in the Imperial Valley rather than to any essential difference in natural conditions. This is proved by the fact that some of the boys mentioned obtained yields from their half-acre fields approximating Salt River Valley figures.

The results of the past summer indicate in a very striking manner the importance of thorough preparation of the land before planting and the need of careful attention to the proper cultivation, irrigation, and thinning of the crop during the early stages of growth in order to secure good yields. It is also clear that while profitable crops of Egyptian cotton may be produced on new land or following grain or a previous crop of cotton, the best results are to be had where cotton follows alfalfa. And, while the evidence is not absolutely conclusive, it seems reasonably certain that cotton should not follow sorghum or milo, which crops appear to have a depressing effect on the following cotton crop.

CHARACTER AND VALUE OF THE CROP.

With but few exceptions, the cotton was picked carefully and the seed cotton as delivered at the gins was clean and free from trash. This made it possible to turn out a high grade of lint. The bales were well packed to a density of from 15 to 20 pounds per cubic foot, and they were well wrapped with burlap bagging. The average tare, including bagging and ties, was about 14 pounds per bale. (Fig. 1.)

In quality—that is, in length and strength of staple—the crop was very uniform and satisfactory. Some of the lint stapled only $1\frac{3}{8}$ inches, but the bulk of it was fully $1\frac{7}{16}$ inches long and some was slightly over $1\frac{1}{2}$ inches long. While the entire crop has not yet been sold, the prices for the sales so far reported have been approximately 21 cents per pound, net weight, delivered on the cars at the shipping point. These prices are said to have been based on the sale of the crop at 23 cents per pound at New England points, the margin of 2 cents being required to pay the charges for freight, brokerage, and other marketing expenses.



FIG. 1.—Bales of Egyptian cotton at Mésa, Ariz., from the crop of 1912. The bales are completely covered with a light-weight yet strong grade of burlap.

A small portion of the cotton was of low grade, due to careless picking, or was of comparatively poor quality, due to bad conditions in the fields. This cotton brought a somewhat lower price. The crop from some fields had to be shipped to assembling points to be made up into carload lots, which increased the cost of transportation. However, the bulk of the crop has brought the producer about 21 cents per pound at his shipping point, which, considering the yields previously mentioned, is a satisfactory return.

In a few cases the grower sold his crop in the seed; that is, unginned. In this condition it brought $4\frac{1}{4}$ and 5 cents per pound, and at this price the purchaser was able to pay the cost of ginning and baling and to sell the fiber at 21 cents with a safe margin of profit.

From the results of the ginning records made during the season it appears that a little less than 1,800 pounds of seed cotton of the Yuma variety may be expected to give a 500-pound bale of fiber. There have been marked variations in this respect. The observed range of percentage in fiber from seed cotton has been from 25.2 per cent to 31.7 per cent, with an average of about 28 per cent for the entire crop.

In the Salt River Valley a large proportion of the seed resulting from the 1912 crop has been reserved or sold for planting in 1913. The price when sold for this purpose has been from $1\frac{1}{2}$ to 3 cents per pound. In the Imperial Valley most of the seed was sold to an oil mill at the rate of \$15 per ton. Some of the seed has been used for feed, and when so used was considered as worth about 1 cent per pound. The seed is a factor of appreciable importance in the crop return. Even when sold to the oil mill it brings a sufficient return to pay more than the cost of ginning and baling the crop.

COST OF PRODUCTION.

The cost of producing Egyptian cotton, exclusive of harvesting the crop, varied between wide limits. It has been possible in a few cases to ascertain the cost of production; that is, the cost of labor and irrigation water, but not including interest on the land investment. On the larger fields, where teams and machinery could be used to advantage, this cost, exclusive of picking, ginning, and baling, ranged from \$11 to \$16 per acre. One of the important factors in the cost of production was the preparation of the land. Where it was necessary to subdue a tough sod of alfalfa and Bermuda grass the cost was high. This was particularly the case where the work early in the season was not done thoroughly. The best results in crop yields as well as the greatest economy of labor were secured where the early tillage was thorough and the land was brought into the best possible tilth before the crop was planted.

The cost of picking Egyptian cotton was no less variable than the cost of production. On the irrigated land of the Southwest the cotton plants grow very large, with many branches. When loaded with a heavy crop the plants bend over and become so entangled that it is difficult to get through the field. (Fig. 2.) Where the acreages were small for each family, no cash outlay for picking was needed. In the Imperial Valley, where labor was scarce and there was a lively demand for pickers in adjacent fields of short-staple cotton, it was sometimes found necessary to pay from 3 to $3\frac{1}{2}$ cents per pound for picking. In the Salt River Valley, on the other hand, the labor supply was adequate and the bulk of the crop was picked for 2 cents per pound. These prices, of course, refer to the seed cotton.

It was found that good pickers averaged about 100 pounds of seed cotton per day where the crop was good. In several cases good

pickers brought in from 125 to 150 pounds per day when conditions were especially favorable. Pickers may be expected to average from 70 to 100 pounds per day throughout the season, and when working at this rate the seed cotton should be delivered very clean and free from trash. On the basis of these results it is estimated that one picker will be required for each two or three acres of cotton. The picking season in 1912 began about the middle of September and closed early in February, 1913, though for the best results it should have closed a month earlier, as the late-picked cotton was generally of poor quality.



FIG. 2.—A field of Egyptian cotton in Arizona, showing the large size of the plants, which makes picking more expensive than is the case with Upland cotton.

The ginning and baling of Egyptian cotton is more expensive than the similar operations for Upland cotton. From the results of last year's experiment it is not possible to estimate with accuracy just what the cost will be when a larger crop is available. The arrangements for ginning the first crop were made more with a view to economy in purchase than in operation, and much of the work was done at a disadvantage. From the data obtained it appears that the ginning and baling cost last year from \$6 to \$10 per bale. The roller gin used for the Egyptian cotton was the same as the one generally used in the Sea Island district of South Carolina and Georgia.

The turnout averaged about 1 bale per day from each gin, though under favorable conditions it was possible to gin $1\frac{1}{2}$ bales with each machine.

The cost of producing an acre of Egyptian cotton, estimating a yield of 1,800 pounds of seed cotton per acre, may be summarized as follows: Seed, tillage, and irrigation, \$15; picking, \$36; ginning and baling, \$10; making a total cost of \$61 per acre, exclusive of interest on land investment. It should be kept in mind that these figures are merely approximations. The actual costs will be found to vary between wide limits, both above and below these figures.

CONCLUSIONS DRAWN FROM THE SEASON'S WORK.

The results of the season's work on Egyptian cotton in the Southwest appear to warrant a material increase in the acreage devoted to that crop. It would appear that farmers, particularly in the Salt River Valley, will be justified in a further trial of the crop and on a much larger scale. The prices paid for the crop were comparable with those paid for imported Egyptian cotton during the same period of sale. It has been demonstrated by repeated experiments that Egyptian cotton of excellent uniformity and good length and strength of staple can be produced on the irrigated lands of southwestern Arizona and southeastern California. The production of Egyptian cotton in larger quantities should result in attracting the attention of users of that staple to this new producing region, and consequently lead to a more advantageous marketing of the crop.

The crop is one which fits admirably into the best rotation system for these southwestern irrigated lands. When cotton is alternated with alfalfa the results are beneficial to both crops and to the productivity of the soil. Alfalfa is and probably will remain the most important single crop of these irrigated lands, but the maximum production of this crop is to be expected only where it is grown in rotation with some cultivated crop, such as cotton, which permits the killing out of the Bermuda grass, Johnson grass, and other weeds which invade the alfalfa fields and after a time greatly reduce their productivity.

For the best results in maintaining a high quality of Egyptian cotton on these irrigated lands, it will be necessary to maintain a supply of pure and carefully selected seed. The variety which has been used by farmers during the past season is the result of several years of selecting and testing. The experiments which resulted in the production of this variety are being continued, and other and better varieties may reasonably be expected in the future.

Meanwhile, it is of the utmost importance that the seed used for planting by the farmers shall be uncontaminated by cross-pollination

with other varieties or types of cotton. In order to insure this, it is very desirable that in each community only one variety or class of cotton be grown. This is important, not only from the standpoint of keeping the seed supply pure, but also in order to avoid confusion in the minds of cotton buyers with reference to the class of cotton produced in each section. It is possible, for instance, for the farmers of the Salt River Valley, by cooperating in maintaining the purity and quality of their seed supply and in carefully handling and harvesting their crops, to develop a reputation for their cotton which will be a commercial asset of great value. Such a result would be impossible if several different kinds of cotton were grown in the same region.

In the Imperial Valley the size of the land holdings and the labor supply are such that it appears desirable for the farmers of that community to specialize on a big-bolled and hence easily picked variety of long-staple Upland cotton, such as Durango, rather than on Egyptian. In the Salt River Valley, however, conditions appear to be more favorable for the development of a cotton industry on the basis of the Egyptian type. There the land holdings are generally smaller, the labor supply more abundant, and it has been demonstrated that fiber of very high quality and value can be produced.

There remain several important steps to be taken by the cotton growers of the Salt River Valley before the cotton industry can be said to be well established. Larger and more efficient ginning plants must be established, and satisfactory arrangements must be made for the disposal of the seed, either by erecting an oil mill in the valley or by marketing the seed at some outside point. The cotton growers should definitely associate themselves for the purpose of establishing and maintaining market grades of cotton which shall be uniform throughout the season and shall fluctuate as little as possible from one season to another. They should also make arrangements for storing the cotton in warehouses after it has been ginned and baled, under circumstances which will make it possible to borrow money upon it until it can be marketed to advantage. It is very undesirable to be compelled to sell cotton as soon as the crop is ginned in order to raise money to pay for the cost of production.

It is also extremely important that every precaution be taken to avoid the introduction of the boll weevil and other noxious insects into the cotton-producing sections. It is by no means certain that the boll weevil will thrive under irrigated conditions in the Southwest, but the risk is too great to excuse negligence in this matter. Finally, it is of the utmost importance to the future of the Egyptian cotton industry in the Southwest that the farmers take up very seriously the question of maintaining an adequate supply of pure seed of high-yielding and uniform varieties.

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AGRICULTURE ON THE YUMA RECLAMATION PROJECT.¹

By CARL S. SCOFIELD, *Agriculturist in Charge of Western Irrigation Agriculture.*

THE SOIL AND TOPOGRAPHY.

The agricultural area of the Yuma Reclamation Project includes about 130,000 acres lying on both sides of the Colorado River in Arizona and California immediately north of the boundary between the United States and Mexico. Of this about 90,000 acres are valley land, formerly subject to overflow by the river, and 40,000 acres are on a bench or mesa directly south of Yuma. This mesa land is about 100 feet above the river and is irrigable by pumping. The valley soil is composed of silt deposited by the river during the annual floods, and much of it is of very recent deposition. The character of the soil with respect to fineness is extremely variable, depending upon the velocity of the water where it was laid down. The irrigable area lies in a narrow strip along the river between low bluffs of gravel which mark the edge of the mesa. Since 1906 the valley lands have been protected from overflows by levees on either side of the river. Prior to that time agricultural operations on the valley land had been precarious, because of the annual floods.

The subsoil underlying the valley is easily pervious to water, and, since it all lies close to the river channel, the ground water is not far below the surface. The height of the underground water fluctuates with the height of the water in the river.

In topography the valley lands are nearly level, with a gentle slope to the south of about 1 foot to the mile. However, there are numerous old sloughs and stream channels left by the river as well as hummocks and sand hills formed from drifting soil. These must be leveled before the land can be irrigated to advantage. This leveling is often expensive, sometimes costing as much as \$80 to \$100 per acre, though the average cost is probably not over \$30 per acre. In its natural condition the valley land was covered with a heavy growth of timber and underbrush. The timber consisted chiefly of cottonwood, willow, and mesquite. The underbrush was arrow weed and a large saltbush. The clearing of the land of timber and underbrush has been expensive, costing from \$5 to \$25 per acre.

¹ Issued May 3, 1913.

The mesa soil is a mixture of fine sand and gravel. It takes water readily at first, but after a few years of irrigation with the muddy Colorado River water it becomes less pervious and tends to pack and bake on drying. There appears to be much less variation in the mesa soil than in that of the valley. Except for a few hummocks, the mesa is smooth, with a gentle slope to the south and west. It lies at the east of the valley and is separated from it by a steep slope. The native vegetation on the mesa is very sparse, being limited to a few desert shrubs and some inconspicuous annual plants. The cost of preparing mesa land for irrigation will be comparatively slight.

About 10 per cent of the valley land on the Yuma Project contains a sufficiently high percentage of alkali salts to render the growing of ordinary farm crops precarious. These salts are composed chiefly of chlorids and sulphates, with very little black alkali. It has been found necessary to provide a drainage system to keep down the water table to a depth from which the capillary action of the soil will not carry the water to the surface. Such a system is now under construction.

THE CLIMATE.

The climate is warm throughout the year, the temperature for a period of 35 years ranging from a minimum of 16° to a maximum of 120° F. Field operations can be carried on throughout the year, and, if it is desired to do so, the land may be used by growing crops practically all the time. The rainfall is light, averaging about 3 inches a year, and is not a factor in crop production.

There is marked difference between the temperature conditions on the mesa and in the valley during the winter nights, when frosts occur. The mesa is almost free from frost, even in the coldest weather, while freezing temperatures are of frequent occurrence in the valley during the winter months. Such comparative records as are available show that the mean minimum winter temperature is about 9 degrees lower in the valley than on the mesa.

AGRICULTURAL DEVELOPMENT.

The valley was first occupied by American farmers in 1890. The early agriculture was confined to the production of grain and alfalfa. For many years the water supply was precarious and the danger from overflow was such as to retard the permanent improvement of the land. Since the construction of the protecting levees by the Reclamation Service and with the installation of irrigation works, which insure an adequate supply of water, there has been more diversification of crops, and much permanent improvement has taken place.

Notwithstanding many efforts to establish other agricultural industries, the production of alfalfa has remained by far the most im-

portant industry of the region. Alfalfa fields that are properly handled yield annually six or seven cuttings of hay that average 1 to 1½ tons per cutting per acre. Except during a few brief periods the price of alfalfa hay has been high. The local demand for hay required for the stock used in the construction of the irrigation works has been relatively large up to the present time, but as the construction work is nearing completion the local demand for hay is likely to become less active.

In addition to the production of alfalfa hay, there has also been an increasingly large production of alfalfa seed. This crop has proved both reliable and profitable. The average yield from 2,824 acres in 1912 was 288 pounds per acre, with a few fields yielding as high as 900 pounds per acre. During the season an alfalfa field produces not only a crop of seed, but four cuttings of hay as well, one cutting being made before the seed crop and the others thereafter. The alfalfa seed has been clean and of good quality, and it has been marketed to advantage through a local farmers' association.

INDUSTRIES IN THE EXPERIMENTAL STAGE.

Several crops have been grown experimentally on the project on a scale large enough to merit consideration. These crops include cantaloupes, watermelons, onions, and sweet potatoes. Of the several causes that have contributed to the failure of these crops industrially the two most important ones are high transportation charges and inexperience in marketing. This applies particularly to cantaloupes and watermelons. In the case of onions the high-priced early market has been occupied by onions from southern Texas, where the crop is two or three weeks earlier than in Yuma Valley, and it has been found possible to ship carload lots of Texas onions through Yuma to Pacific coast markets before the Yuma crop was ready to harvest.

Many other crops have been tried on the project, including grain crops, cotton, small fruits, and vegetables. Wheat, barley, and rye are planted in the fall and are harvested early the following summer in time to permit the production of a crop of corn, milo, or kafir on the same land. Barley is also extensively planted for hay. Alfalfa fields that have been run out by Bermuda grass are frequently broken up in the fall and planted to barley or wheat. Beans have been produced on a field basis, but with few exceptions have not proved a very remunerative crop. The citrus fruits, including oranges, grapefruit, and lemons, have been grown successfully on the high mesa, while pears, peaches, apricots, plums, figs, dates, almonds, and strawberries have been grown on a sufficiently large scale to prove the adaptability of the valley lands to their culture. Practically all the common vegetables have been grown with success when put in at the

right season and properly cared for. For instance, potatoes, cabbage, lettuce, radishes, and carrots are planted during the autumn months, while such vegetables as tomatoes, eggplant, cucumbers, and melons are planted after danger from spring frosts is over.

THE KIND OF CROPS NEEDED.

Present conditions indicate that the Yuma Project must develop along the line of producing crop products which are sufficiently high priced to bear the cost of long shipment to consuming markets. It is not probable that the local consumption of crop products will ever be a factor of large importance. The natural conditions of climate, soil, and water supply are such as to favor a very large production per acre. The important thing now is to determine which of the many possible crops promise to give the largest returns and to select those which provide for the most suitable utilization of the farm labor and at the same time provide for suitable crop rotation.

It is not to be expected that unless a large development of livestock industries takes place there will long continue a satisfactory market for alfalfa hay. The alfalfa seed crop, however, should remain a profitable one unless some serious disease or insect pest appears. But alfalfa production, whether for hay or seed, is more profitable when the land is occasionally cleaned up by the production of some cultivated crop. This is particularly true where, as at Yuma, the alfalfa fields are quickly invaded by Bermuda grass and high production of hay can be expected only during the first few years. While it is true that a fair seed crop may be obtained from alfalfa fields which are badly infested with Bermuda grass, it is inadvisable to allow such fields to remain, because of the increased cost of subjugating the Bermuda soil and fitting the land again for other crops.

CROPS SUITABLE TO THE REGION.

Of crops suitable for rotation with alfalfa there might be mentioned Indian corn, milo, beans, wheat, barley, and cotton. While such crops as corn, milo, beans, wheat, and barley are all relatively low priced, the climate is such that the small grains can be grown during the winter months and followed by corn, milo, or beans, giving two crops from the same land in one year. Cotton, on the other hand, occupies the land during practically the entire season, but if the proper variety is used the net returns should be larger than for the grain crops mentioned. Cotton is particularly well adapted to rotation with alfalfa because of the high production possible on alfalfa sod.

Cotton is especially useful in subjugating land infested with Bermuda grass and Johnson grass. It requires comparatively little

irrigation but much cultivation during the early summer, and later the plants shade the ground so effectively that Bermuda grass may be completely eradicated by a single crop of cotton. Cotton possesses the additional advantage of relatively high value in proportion to transportation cost, besides finding a ready cash market at all times. It is not quickly perishable and may thus be held without risk in case market conditions at harvest are not favorable.

While alfalfa in rotation with cotton may serve as the basis of a profitable agriculture, particularly if accompanied by one or more of the possible animal industries, it is to be expected that several of the more intensive plant industries, such as orchard fruits, will be developed.

From present indications it seems probable that certain varieties of pears, such as Bartletts (both early and late), Winter Nelis, and Seckel will do well.

The date palm thrives well on the Yuma Project, and as soon as an adequate supply of offshoots of good varieties is available this crop should become a very profitable one. Meanwhile it is possible to purchase seeds in large quantity, and a good proportion of the seedling date palms are likely to yield fruit suitable for home consumption and home market. Moreover, the chance of obtaining valuable new varieties among the seedlings is not to be overlooked.

Another orchard fruit of much promise in the Yuma Valley is the fig. There are two important classes of figs, both of which grow well at Yuma—the Smyrna and the common fig. The latter class includes such varieties as the Brown Turkey, White Adriatic, and Black Mission, which yield fruit without cross-pollination. With proper orchard handling two crops of fruit may be produced every year. The fresh fruits of these varieties find a ready and increasingly large sale, and they may also be dried or preserved before selling.

The Smyrna fig differs from the common fig in requiring cross-pollination. The fresh fruits are marketed to some extent, but the Smyrna-fig industry is based on the dried fruit. While it remains to be demonstrated whether or not the Yuma Valley is adapted to the production of Smyrna figs, it seems worth a thorough trial. Figs are well suited to the orchardist operating on a small scale, because the packing operations, whether for the fresh or dried fruit, are relatively simple and inexpensive. The product is also high priced, and consequently the transportation charge is proportionately small.

CONCLUSIONS.

The fullest agricultural prosperity of the Yuma Reclamation Project requires the utilization of crops which can be combined in suitable rotation systems and which yield products that can be shipped long distances to market.

Alfalfa and live stock are likely to be the principal features of this agriculture, at least at first.

The orchard fruit crops, such as dates, figs, and pears, may gradually become important.

Alfalfa seed production has been profitable, and it is probable that with more experience in producing and marketing it may be made still more so.

Egyptian cotton promises to find a prominent place among the annual crops and is particularly suitable for rotation with alfalfa.

A number of other crops are worthy of trial.

[Cir. 124]

EFFECTS OF CROSS-POLLINATION ON THE SIZE OF SEED IN MAIZE.¹

By G. N. COLLINS, *Botanist*, and J. H. KEMPTON, *Assistant, Office of Crop Acclimatization and Adaptation Investigations*.

INTRODUCTION.

There is a popular belief that the immediate effect of planting two varieties of maize in close proximity is to increase the yield of both varieties. Failure to appreciate some of the peculiar characteristics of the maize plant accounts for the delay in bringing this question to the test. With other crops the changes which follow crossing become apparent only when the hybrid embryos develop into plants in the next generation after the crossing takes place. In maize, however, foreign pollen often has an immediate effect in altering the color and texture of the seeds, a phenomenon that has received a special name, *xenia*. It seemed, therefore, not unreasonable to believe that the size of the seed as well as the color or texture might be affected by crossing.

In connection with a study of hybrids between United States varieties and a new type of maize from China it was observed that one of the effects of crossing the two types was an increase in the size of the seed in the same year the crossing was done.² Similar results in crosses of this Chinese variety have been recorded by Roberts.³

Additional data on this subject were obtained in connection with an experiment planned to test the possibility of selective pollination in maize. Pollen taken from two plants belonging to different varieties was mixed and applied to the stigmas or silks of one of the varieties, thus producing pure and hybrid seed on the same ear. The phenomenon of *xenia* made it possible to so select the varieties with respect to color of the seed that it was possible to distinguish between the hybrid seeds and those resulting from the pollen of the same variety.

¹ Issued May 3, 1913.

² Collins, G. N. A new type of Indian corn from China. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 161, p. 13, 1909.

Roberts, H. F. First generation hybrids of American $\times$ Chinese corn. American Breeders' Association, Annual Report, v. 7/8, p. 374, 1912.

The hybrid and pure seeds from each of the ears, when weighed separately, exhibited such striking differences that it is thought advisable to place the results on record. In every instance the hybrid seed was larger than the pure seed borne on the same ear, the increase ranging from 3 to 21 per cent.

LIST OF VARIETIES CROSSED.

The experiments involved the following varieties:

Missouri Cob Pipe, or Collier.—The well-known, large-cobbed variety used in the manufacture of corn-cob pipes. The seeds are white. In our specimens the average weight per 1,000 seeds is 310 grams.

Gracillima.—A variety of pop corn isolated from a variegated variety, the seed of which was originally secured from Germany. The seeds are white. The average weight per 1,000 seeds is 67 grams.

Variegated.—Similar to the preceding. Isolated from a podded variety. The white seeds of this strain average 141 grams per 1,000 seeds.

Hickory King.—A large, thin-seeded, white dent variety. The seeds of the strain used in these experiments averaged 480 grams per 1,000.

Mexico Black.—A Mexican variety with slightly dented "shoe-peg" seeds and an intensely black aleurone. The original seed of this variety consisted of one ear secured from the Valley of Mexico, Seed and Plant Introduction No. 27074. The seeds of this ear averaged 295 grams per 1,000. As grown in our experiments the seeds are smaller, averaging only 231 grams per 1,000.

Algeria.—A variety of pop corn with beaked seeds and purple aleurone. The average weight of the seeds is 125 grams per 1,000.

DESCRIPTION OF THE EXPERIMENTS.

It will be seen that the varieties involved comprise four with white seeds and two with colored seeds. The color in these seeds is located in the aleurone cells, the outer layer of the endosperm. Previous experiments have established the fact that when pollen from one of these black-seeded varieties is used to pollinate an ear of the white varieties the resulting seed is colored.

In the experiments to be described, the silks of the white-seeded varieties were dusted with a mixture of pollen from the same white variety and pollen of a different variety with colored seeds. The ears that result from an operation of this kind have white kernels that represent pure seed of the variety and colored seeds that are hybrids between the white and colored varieties. In some instances the pollen of the white variety contributed to the mixture was taken

from the same plant that was being pollinated, in which case the resulting white seeds were not only pure for the variety, but were self-pollinated. The two kinds of seeds were, of course, mixed indiscriminately on the ear and developed under identical conditions. Where consistent differences in the size of the two kinds of seed occur it is therefore safe to assume that they are due to differences induced by the use of the various kinds of pollen. The number of seeds from a single ear are usually large enough to afford reliable averages and justify confidence in even relatively small differences.

Eleven such ears were secured, and the results with respect to the weight of the hybrid and pure seed are given in Table I. Individual plant numbers are given, since in many instances a plant which bears one of the pollinated ears also figures as the source of pollen in another cross. Where more than one ear of a plant was pollinated the second and third ears from the top of the plant are given the individual plant number followed by a figure 2 or 3. To avoid large decimals, the average weight is given in terms of 1,000 seeds instead of in terms of a single seed.

It will be seen that in every instance the size of the seed was materially increased by the foreign pollen. The increase ranges from 2.8 to 21.1 per cent. It should also be noted that the rate of increase bears no direct relation to the size of seed in the variety used as the source of pollen. The seeds of the Algeria variety average only half as heavy as those of Mexico Black, yet the increases secured when Algeria is used as the source of pollen are rather greater than when Mexico Black pollen is used.

TABLE I.—*Increase in size of seed secured by cross-pollination.*

Ear-bearing plant.		Source of the mixed pollen.				Number of seeds.		Weight per 1,000 seeds.		Increase with cross-pollination.
		White.		Colored.						
Variety.	No.	Variety.	Plant No.	Variety.	Plant No.	Pure.	Hybrid.	Pure.	Hybrid.	
								<i>Grams.</i>	<i>Grams.</i>	<i>Per cent.</i>
Pipe.....	259	Self.....	.....	Mexican Black.	643	511	220	294	337	14.6 ± 0.7
	259-2	Pipe.....	267	do.....	643	541	248	268	293	9.3 ± 1.0
	267	Self.....	.....	do.....	643	553	23	371	420	13.2 ± .6
Gracillima.....	1212	do.....	.....	Algeria.....	1301	171	235	65	79	21.1 ± .9
	1223	do.....	.....	Mexican Black.	669	99	211	74	80	7.9 ± .8
	1221-2	Gracillima	1212	do.....	669	350	94	66	74	12.3 ± 1.4
	1221-3	do.....	1212	Algeria.....	1301	139	175	65	74	13.8 ± 2.1
Variegated.....	1227	Self.....	.....	Mexican Black.	653	402	81	137	156	13.9 ± 2.2
	1227-2	Variegated	1228	do.....	653	111	245	140	148	5.7 ± .6
	1228	do.....	1227	do.....	653	496	25	144	148	2.8 ± .9
Hickory King..	219	Self.....	.....	do.....	643	140	104	522	557	6.7 ± .2

VOLUME AND SPECIFIC GRAVITY OF SEEDS.

The differences in weight observed in these seeds might come about through differences in size or through differences in composition, or a combination of both. To determine this point, volumetric and specific-gravity determinations were made of the pure and hybrid seed of all the ears. The results showed that the observed differences in weight were associated with corresponding differences in volume. No differences in the specific gravity of pure and hybrid seed from the same ear could be detected.

SIZE AND COLOR NOT CORRELATED.

In order to distinguish between pure-bred and hybrid seed on the same ear only those hybrids with colored aleurone could be utilized. It might be urged that there was a tendency for colored seeds to be heavier than white and that we have been measuring differences between colored and white seed rather than differences between pure and hybrid seed. Fortunately, there was material at hand to test this point. In 1911 a cross had been made between Variegated and Mexico Black, two of the varieties used in these experiments. This hybrid was grown and a number of self-pollinated ears secured in 1912. These ears all had both white and colored seeds. A comparison of the weight of the white and colored seed from each of these ears showed only the ordinary fluctuating differences between the two classes.

SELECTIVE POLLINATION AND CROWDING OF SEED.

Before accepting the increased size of the hybrid kernels on mixed ears as an indication of the increased yields that may be secured from cross-pollination, it will be necessary to consider the possibility that the hybrid kernels might develop at the expense of the neighboring pure kernels. In that case the average size of the seed would not be increased if all the seeds of the ear were cross-pollinated.

If the pure kernels are weak or develop more slowly, the hybrid kernels may gain by being less crowded, or the hybrid kernels may grow more rapidly at first because of more prompt pollination and may then rob their pure-seed neighbors by direct appropriation of a larger share of the available food materials.

A fortunate accident in pollination throws light on both of these questions. An ear of "Maryland White Dent" was pollinated by a plant of the same variety. Seven days later, in making a second application of pollen, a plant belonging to a red variety with yellow endosperm was accidentally used as the source of pollen, the mistake being noted at the time.

In the resulting ear the two kinds of seed were easily distinguished. The pure seeds resulting from the first pollination were pure white, while the hybrid seed resulting from the second pollination were yellow. Unlike the ears where mixed pollen was used, the two kinds of seed were not indiscriminately distributed. All the white seeds were on the lower portion of the ear; all the colored were on the upper portion. This segregation of the two kinds of seed must have deprived the hybrid seed of any advantage that might be secured by crowding weak neighbors, while the time which elapsed between the two applications of pollen precluded the possibility of the hybrid seed appropriating material in advance of the pure seed.

The ear produced 212 white, or pure, seeds and 161 that were yellow, or hybrid. The average weight of the pure seed was 283 grams per 1,000. The average weight of the hybrid seed was 292.5 grams per 1,000, a difference of 9.5 ± 1.06 grams, or 3.4 per cent. The seeds on the lower portion of the ear are usually somewhat larger than those on the upper portion, a fact that should be considered in connection with the observed increase.

CONFLICTING RESULTS OF PREVIOUS INVESTIGATIONS.

As soon as the phenomenon of xenia came to be recognized, the possibility that size might be among the characters thus affected was perceived by a number of investigators; but, without some method of mixed pollination similar to that used in our experiments, changes in the size of seed could only be measured by comparing the average size of seed from hybrid ears with the average size of seed in the parent variety. There is such a range of individual variation in maize with regard to the size of seed that hybrid ears would have to be produced in very large numbers to recognize any but very large differences. Since hybrid ears were secured only through artificial pollination, their number was naturally small and it is not surprising that the results were more or less contradictory.

Thus Correns¹ made a series of crosses between races with different-sized seed and compared the weight of the hybrid and parent varieties. He viewed the results, however, from the standpoint of the inheritance of size as a character and paid little attention to the possibility of this being an increase due to crossing as such. With the limited number of ears which he secured it was hardly to be expected that increases of less than 25 per cent could be detected with certainty. In summarizing his results on this point, he states that while the size of the seed is not essentially changed by cross-pollination there is a slight increase in weight. By the method of mixed pollination used in our experiments differences averaging as low as 2 per cent are significant.

¹ Correns, Carl. Bastarde zwischen Maisrassen, Stuttgart, p. 30, 81, 1901. (Bibliotheca Botanica, Heft. 53.)

In cases where the ear-bearing plant produced two ears it was hoped that the effect of cross-pollination might be measured by pure seeding one of the ears and using foreign pollen on the other. In this way it might be possible to determine the effects of crossing two varieties with seed of the same color. But the normal range of variation in the size of seed between the first and second ears of the same plant when both were pure seeded was found to be so large as to obscure any differences that might be expected from the use of foreign pollen.

NATURE OF THE INCREASE.

The Chinese variety in which the phenomenon of increased size was first noticed has very small seeds, suggesting that the increase that followed crossing should be looked upon as the immediate inheritance of larger seed of the pollen parent. The other alternative is to consider the increased size of the seed as connected with the greater vigor so frequently shown in the first generation of a cross.

Roberts¹ finds difficulty upon morphological grounds in admitting the possibility of this second view. He holds that the growth stimulus of the pericarp must be inherited from one of the parents and that additional growth that resulted from a mere increase of vigor would produce an endosperm too large for the pericarp.

In the experiments here reported there is no evident relation between the size of seed in the pollen-producing variety and the amount of increase resulting from cross-pollination. In fact, the greatest increase was secured by pollinating with a small-seeded variety, and there is one instance (plant No. 219) where an increase in the size of the seed of the large-seeded Hickory King variety was secured by pollinating with a variety whose seeds weighed only half as much as those of the Hickory King. It may be necessary to conclude that the growth of the pericarp is stimulated directly by the growth of the endosperm. In experiments thus far reported, however, the necessary increase in the size of the pericarp would be comparatively slight and to seek any explanation may be superfluous. An increase of 22 per cent in the volume of a seed, which is the largest reported, would require an increase in the superficial area of the pericarp of only about 2.8 per cent.

If an increase of from 2 to 20 per cent in the weight of the seed can be secured through the stimulation of foreign pollen, the fact is of more than scientific interest. Direct evidence that important increases can be secured by allowing two varieties of the same color to cross-pollinate has been given by Carrier,² who secured yields of

¹ Roberts, H. F.

² Carrier, Lyman. Loc. cit. Preventing cross-pollination of corn by means of muslin screens. Paper read before the American Society of Agronomy, Washington, D. C., Nov. 14, 1910.

from 5 to 18 bushels more per acre when strains were allowed to cross-pollinate than when cross-pollination was prevented.

Another idea suggested by the results of these experiments is that increase in the size of the seed in the xenia generation may serve as a means of determining in advance the hybrid combinations that will produce vigorous and productive plants the following generation. Whether this proves to be the case or not, the results afford additional reason for the use of first-generation hybrid seed; but even where hybrid seed is not to be used, the planting of two varieties in alternate rows may be found to increase the yields sufficiently to warrant the additional trouble.

As the increased size is evidently a manifestation of vigor, it may be considered as a factor of adaptation, like the vigor of the first-generation hybrid plants. It would seem especially desirable to take advantage of this method of increasing the yield in regions which do not produce their own seed corn.

CONCLUSIONS.

The experiments reported in this paper afford definite evidence that the crossing of two varieties of maize is followed by an increase in the size of seed in the same year that the crossing is done. This increase is not to be confused with the increased yields secured in the year following, when the first-generation hybrid plants are grown.

By mixing pollen of a white-seeded and a colored-seeded variety and applying the mixture to the silks of the white-seeded variety pure and hybrid seed are produced on the same ear. By virtue of the xenia inheritance of seed color the two kinds of seed produced under identical conditions can be distinguished and compared.

This method makes it possible to measure the immediate increase from cross-pollination much more reliably and accurately than can be done in any experiments involving the comparison of seed produced on different plants. The results showed the hybrid seed to be heavier in every instance, the increase ranging from 3 to 21 per cent.

EXPERIMENTS ON THE DECAY OF FLORIDA ORANGES.¹

By J. G. GROSSENBACHER, *Pathologist, Fruit-Disease Investigations.*

INTRODUCTION.

The oranges that dropped and decayed in many groves in Florida during the past season probably amounted to half of a medium-sized crop, but the trees had been so heavily loaded to begin with that the citrus growers generally had a very profitable year. Dropping and some decay first became very noticeable in severely ammoniated² groves during the latter part of October and gradually increased until the first part of December, 1912, when not only was the ground beneath the trees of ammoniated and melanosed groves covered with moldy fruit, but many trees had large numbers of decaying oranges still attached. The musty, moldy smell of such groves was noticeable at some distance. In a few small sections of the State melanose and ammoniation were practically absent. In these sections the "drops" were comparatively few, and decay, both on the trees and in transit, seemed no greater than in other years. As might have been suspected, the heavy losses from decay in shipping were chiefly confined to the sections and groves in which the dropping of fruit and decay, both on the ground and on the trees, had been great. During most of December it was not uncommon to hear reports of 20 to 60 per cent of decay in transit to market from such sections, and sometimes as high as 80 per cent decayed.

The causes of this great loss by dropping and decay are, perhaps, several and may be very complex, but it seems likely that the conditions responsible were, at least in part, the same as those causing decay in transit. While the most active agents of decay apparent in the groves during fall and early winter were the blue molds, it is not so evident how these rot organisms gained entrance to the fruits, except in so far as rinds had split or had been broken in some other way. In October and again in December, many oranges in very early stages of decay were found still attached to trees, and by careful examination with an ordinary hand lens it was sometimes possible to find one or more very minute clefts in the rind near the

¹ Issued May 3, 1913.

² The words "ammoniation" and "melanose" are frequently used in this paper for brevity in referring to groves having ammoniation or die-back spots and melanose roughenings on the fruit.

center of such a softening area, although in some cases no imperfections or breaks could be seen. Only rarely could a bright orange be found rotting on a tree, but usually decaying fruit was ammoniated or severely melanosed.

THE CAUSES OF DECAY.

This paper on orange decay as it occurred in Florida during the past season aims only to bring together some of the most obvious facts as related to that particular epidemic. The attention is centered chiefly on the weather conditions, diseases, and other injuries sustained by the fruit in the groves and the relation of these factors to decay. As the rot of oranges resulting from improper handling is only indirectly related to decays due to the natural environment it is unnecessary to discuss here the question of fruit handling. That phase has been fully investigated and some of it has been reported.¹

STIGMONOSE AS RELATED TO MOLD INFECTION OF FRUITS.

In December, 1912, while looking more particularly for agents that might aid in infecting fruits which have a perfect rind, several species of pumpkin bugs or stinkbugs were found sticking their long beaks into oranges and apparently sucking the juice from the fruits. It is, of course, uncertain just how effective such punctures are in carrying the mold spores which may be present on the rind into the fruit, but since the bugs were fairly common and could often be seen making three or four punctures in a few minutes it is probable that only comparatively few of their punctures caused infection, in spite of the fact that the mold spores were plentiful throughout the groves. On making hand sections of such orange rinds, especially where very tiny discolored spots could be found in the rag or where one or more pulp cells were found partially empty or discolored, it was sometimes possible to get fairly good views of the path of the puncture through the rind by the rod of yellow gumlike substance which occupied its place. No indication of the puncture was visible on the surface view, even after such a canal or rod had been exposed in section. The surface cells seem to close in on the withdrawal of the beak. In a number of such sections of orange rinds the tissue of the inner portion of the outer rind surrounding a bug puncture was found dead and discolored, but it was impossible to demonstrate the presence of a fungous mycelium in these inconspicuous early stages. Nevertheless, it is likely that this stigmonose of the orange was responsible for many mold infections and considerable decay during the height of the period

¹ Tenny, L. S., Hosford, G. W., and White, H. M. The decay of Florida oranges while in transit and on the market. U. S. Department Agriculture, Bureau of Plant Industry, Circular 19, p. 8, 2 fig., 1908. See also Ramsey, H. J., Proceedings, Florida State Horticultural Society, 1912.

of rot in December. Infection with mold by means of stinkbug punctures would, of course, not be evident until the oranges had become soft. The manner of infection would also be mysterious, because no evident injury could be found on the rind. Figure 1 is a camera drawing giving a good general idea of these punctures and the early stages of disorganization surrounding them. Possibly some of the disintegration is due simply to a poison secreted by the mouth parts of the insects. It so happened that in February, when decay in the groves was very slight as compared to that occurring in December, no stinkbugs could be found in the groves.

WET WEATHER AND SPLITTING INDUCING DECAY.

The very wet weather prevailing during practically the entire summer was doubtless indirectly responsible for most of the rot, not only because it favored the occurrence of both ammoniation and melanose in great abundance, but thereby also resulted in many clefts in the rind, some large and some small. These rind injuries, in connection with the abundance of blue-mold spores, were, perhaps, the greatest immediate cause of decay in the groves, as well as of the earlier part of the heavy decay in transit.

The creasing and splitting of oranges occur commonly in the fall and winter following a wet season or after a wet period preceded by a drought. A drought checks the growth of the fruit and hardens the rind and, if followed by good growing weather, ruptures may occur. However, when wet weather lasts all summer, ammoniation and melanose are likely to be abundant and consequently result in many splits.

The forces which actually cause the creasing and splitting have not been determined, but have been deduced from the conditions of

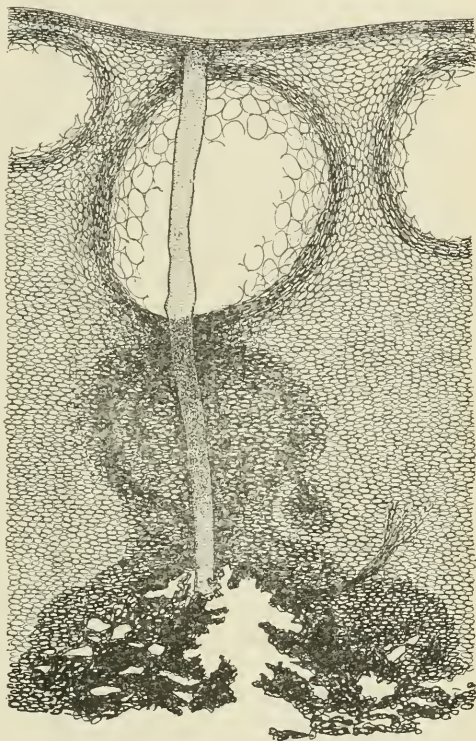


Fig. 1.—Section of orange rind, showing gummosis tube or rod where beak of insect had punctured and disintegration of tissues from within outward. Magnified to about 26 diameters. Drawn by J. Marion Shull.

weather and growth prevailing during the seasons when ruptures of the rind are prevalent; that is, the facts observed have been pieced together and the gaps existing in our knowledge filled in by assumptions in such a way as to make a more or less complete story. This theoretical explanation is only provisional and awaits the results of experimental examination before it can be considered a real explanation.

Many orange rinds sustain ruptures during or after a prolonged wet period following a drought which prevailed while the fruit was making the latter part of its growth. The growing weather following such a drought causes the pulp to renew its growth and distend the rind. Since the tissue of the inner rind, or rag, loses its vitality before that of the outer or oil-bearing portion, its stretching capacity is more limited and, therefore, more often ruptures, while the outer rind becomes simply more distended. However, when wet weather prevails throughout the summer, as in 1912, the growth of the pulp may be practically continuous, but, owing to the fact that such a wet season is accompanied by the development of ammoniation and melanose, the outer rind loses its capacity for continued growth and distention and therefore splits. When the outer rind is bright or uninjured, it may be stretched to meet considerable increase in the size of the pulp mass; and if ruptures occur under such conditions usually only the inner rind, or rag, is ruptured, resulting in what is known as creased fruit. In either case the rind of such fruits is found to be very tight or under a very high internal pressure at the time the ruptures occur.

If oranges which have an internal growth-and-sap pressure almost great enough to burst the rind were placed in a strong air-tight vessel into which more air is pumped until the air pressure inside the vessel is much higher than that outside, the rind on the inclosed oranges would become fairly loose, simply because the air pressure on the outside of the oranges (in the vessel) is now much greater than the growth-and-sap pressure inside the oranges. On the other hand, if, instead of pumping more air into the vessel containing the oranges, air is pumped or drawn out so that the air pressure inside the vessel is much less than the pressure outside, the expansive forces inside the oranges (growth-and-sap pressure) will be so much less restrained by the diminished air pressure surrounding the inclosed fruits that their rinds will burst. In other words, if the pressure in the oranges has reached a height which is almost sufficient to result in creasing or splitting and then a period of low barometer or low atmospheric pressure comes on, there are almost certain to be many split or creased fruits, while a rise of the barometer or an increase in the atmospheric pressure would probably have prevented the

ruptures. The position and tension of the orange rind is a resultant of the interaction between the internal pressure existing in the fruit and the resistance of the rind and atmospheric pressure outside.

MELANOSE AND AMMONIATION AS RELATED TO THE OCCURRENCE OF DECAY.

As intimated, a rather striking constancy was noticeable in the prevalence of melanose and ammoniation in groves where many fruits were decaying both on the ground and on the trees. It was also noticed that the unusually high percentage of decay of oranges in transit during late November and the month of December was confined almost wholly to those sections of Florida in which the fruits were affected with melanose and ammoniation. In other words, the only sections of the State in which rot was not heavy were the few in which the oranges were neither melanosed nor ammoniated.

Whether it is possible to introduce some factors which would prevent such a wholesale dropping and decay in the groves can not be definitely stated at present, but the question is important enough to merit some very careful study. In a detailed study of the factors in picking and packing fruit which contribute to decay in transit, valuable and suggestive results have been obtained by the Office of Field Investigations in Pomology of the Bureau of Plant Industry. It was demonstrated beyond a doubt that by the older and more careless methods of picking and handling the fruit a considerable amount of decay was induced by injuring the rinds in various ways. But the difference between the decay ordinarily due to such careless handling and that which occurred last year in the oranges from most of the State is very evident and is quite large. A number of carefully run packing houses located in regions where melanose and ammoniation were prevalent sustained heavy losses from rot in transit in spite of the additional care taken to avoid the trouble. On the other hand, some packing houses doing business in sections free from melanose and ammoniation experienced but little more than the ordinary amount of rot in transit. In view of such results obtained in the uncommon years, it seems advisable to continue the study of the decay of oranges in transit and to pay special attention to factors in the groves that may be related to the occurrence of such extraordinary seasons as the one just past.

The unusually high percentage of decay in severely melanosed and ammoniated groves, as well as the enormous loss in transit from such groves when compared with results obtained in groves free from both of these diseases, indicates either that melanose and ammoniation on oranges predispose them to rot or else that the conditions

favoring the development of melanose and ammoniation are themselves the predisposing factors. In quite a number of groves where the splitting, dropping, and decay amounted to perhaps a fifth of the crop, ammoniation was the only kind of rind injury to be found. Once all the details of the cause of ammoniation are known, it may be possible to prevent much of this loss.

THE RELATION OF MELANOSE TO STEM-END ROT.

In view of the paper recently published by Floyd and Stevens,¹ in which some suggestive evidence is given to show that melanose is due to the same fungus that causes stem-end rot, it seems highly probable that by preventing melanose at least a portion of the decay can be prevented.

EXPERIMENTS ON THE PREVENTION OF MELANOSE.

Some experiments are now under way on the prevention of melanose under grove conditions. Lime-sulphur as well as Bordeaux mixture is being used as nearly as possible according to the suggestions given in the above-mentioned paper by Floyd and Stevens. In case the disease is prevalent again this year it will be possible to get some idea of the feasibility of using a fungicide for its control.

DOES STELLATE MELANOSE ON LEAVES HARBOR PHOMOPSIS CITRI?

Even in a season like the last, when the leaves, young growth, and fruit of thousands of both pomelo and orange trees are literally covered with melanose roughenings, very few fruiting bodies of the causal fungus were found on the dead twigs of such severely affected trees. That makes one wonder what could have been the source of all the infectious material required to produce such untold millions of infections. It appears that ordinarily *Phomopsis citri* is not to be found in the melanose roughenings on the leaves, shoots, or fruits. The injury resulting in the rough spots is thought to be due to some enzymotic substance liberated by the spores of the fungus on germination. The melanose spots are usually pinheadlike cushions of cork raised above the general surface of the citrus tissues, but in some cases a later enlargement of these circular spots occurs, in that three or more short ridges develop as radii about the original circular spot. This stellate form of melanose was found very abundantly during February and March, 1913, in one of the smaller orange groves of the Manatee Fruit Co. near Pabnetto. Now, since the fruiting bodies of the *Phomopsis* are so few on the dead twigs of severely affected trees,

¹ Floyd, B. F., and Stevens, H. E. Melanose and stem-end rot, Florida Agricultural Experiment Station, Bulletin 111, 16 p., 9 figs., 1912.

it was thought possible that under certain unknown conditions the fungus may actually be present in the original melanose spots and by further growth induce a development of stellate spots and finally produce spores and thus infect the new growth of leaves, fruits, and shoots. These stellate melanose spots have been studied carefully in thin sections, but fungus mycelium could not always be found in them, although some was often present. The accompanying illus-



FIG. 2.—Stellate melanose spots on upper side of orange leaf, showing the older circular spots in the center. Magnified about $7\frac{1}{2}$ diameters. Photographed by Dr. Albert Mann.

trations (figs. 2 and 3) give a fair idea of the stellate spots as they appear under an ordinary magnifying glass.

EXPERIMENTS TO DETERMINE THE CAUSE OF DECAY.

Since the general opinion prevailed, both among the growers and shippers, that the rot was chiefly due to *Penicillium* or mold and because the heavy decay was confined to groves that had melanosed and ammoniated fruit, it seemed worth while to determine what relation could be shown to exist between those rind diseases and decay.

A TEST AT ORLANDO.

In order to make a preliminary test, bright, ammoniated, and melanosed oranges were carefully picked in early February near Orlando, Fla., and sprayed with blue-mold spores obtained from wholly decayed oranges secured from a packing house near the

Orlando Field Laboratory. After drying, five bright, five melanosed, and five ammoniated fruits were wrapped and put into separate covered glass vessels. The vessels were stored on shelves in the laboratory. Twelve days later the following results were found: In the dish containing the melanosed oranges one was about half decayed and two others were slightly softened at the stem end, but no blue mold was evident. In the dish containing the ammoniated fruits two were entirely decayed and the blue mold had covered the outer surface of the paper wrappers with its spore masses; another orange



FIG. 3.—Stellate melanose as occasionally seen on the under side of leaves. Magnified about 7½ diameters. Photographed by Dr. Albert Mann.

was about one-fifth decayed at the stem end, but had no blue mold in evidence. The bright fruits were apparently as good as when picked two weeks before. Although these numbers are small, the results are suggestive, because they are so pronounced on fruits which had been carefully picked and handled. The difference between the 60 per cent of decay of the rough-rinded oranges and the entire absence of decay in the bright fruit was so great that it was decided to make further tests. It appeared rather extraordinary that half of the oranges were decaying by an organism distinct from the one used in the water sprayed on the fruit.

THE FIRST TEST IN WASHINGTON.

It also seemed possible that oranges from a vigorous tree might prove more resistant to decay than those from a tree that had been much weakened by crown-rot (foot-rot), even when the rind of both is in about the same condition. In order to open the way for some future work along that line, melanosed fruits were selected from both normal and foot-rotted trees and carefully marked when packing. Ammoniated fruits were taken from vigorous-looking trees.

The fruit was carefully packed and expressed to Washington, D. C., from Orlando, Fla., on February 28. Owing to unforeseen conditions, it had to be held in Washington at room temperature until March 10 before being unpacked to start the experiment. At that time several ammoniated oranges were found decayed, apparently by blue mold, and several melanosed fruits and one bright orange were in the early stages of stem-end rot, as indicated by obtaining *Phomopsis citri* from their interior. A number of melanosed and ammoniated fruits were rather soft and flabby. Only the firm ones were used in the experiment, the details of which are given in Table I. A portion of each type of fruit was sprayed with water by means of an atomizer, and the other fruit was sprayed with a suspension of the *Penicillium* or mold spores obtained from vigorous pure cultures formerly secured from moldy oranges. The mold used seems to be most like *Penicillium italicum*, but at present its identification is uncertain.

After drying, the fruits were wrapped with ordinary orange wrappers and each kind placed in separate covered glass dishes. The fruit was all held at room temperature for three days and then some was transferred to a refrigerator having a temperature of about 15° C. (60° F.). On March 17, or a week after the beginning of the experiment, the oranges were all carefully examined for decay, and cultures were made from the interior of many of the fruits which seemed to be affected by stem-end rot, although the decay was not of sufficient extent to be certain. All but two of such doubtful ones were found to contain *Phomopsis citri*. The fungus obtained from the two other oranges proved to be neither *Phomopsis* nor *Penicillium*, and not having produced its spores as yet in culture it still remains unknown. The relation of *Phomopsis citri* to stem-end rot was established by Fawcett,¹ who also showed that the decay is not preventable by the application of a fungicide.

¹ Fawcett, H. S. Stem-end rot of citrus fruits. Florida Agricultural Experiment Station, Bulletin 107, 23, p. 9 figs., 1911.

Several interesting facts are evident from the data recorded in experiment 1 of Table I. Perhaps the most striking thing here is that fruits treated with mold spores were but little more subject to decay than those not so treated. Another important point that may have a wide practical bearing if further experiments confirm it is the fact that even though three days were allowed for the incubation of the oranges treated with blue mold before they were removed to a temperature of 15° C. (60° F.), no case of blue-mold decay resulted in the refrigerator in a total of 19 sprayed with spores. Of the total number of fruits decayed, only 28 $\frac{4}{7}$ per cent were rotted by blue molds, while 71 $\frac{3}{7}$ per cent decayed by stem-end rot. Two of these fruits rotting at the stem end were afterwards shown to contain a very rank-growing fungus which has not yet sporulated in culture, while the others contained *Phomopsis citri*. It is also worth noting that of the oranges sprayed with *Penicillium* spores and held at room temperature throughout the experiment, 38 $\frac{1}{2}$ per cent decayed at the stem end and only 10 $\frac{1}{4}$ per cent had blue mold. Of the total of 58 oranges treated with mold spores, 24 decayed; of these, 20, or 83 $\frac{1}{3}$ per cent, were decayed by *Phomopsis*, while only 16 $\frac{2}{3}$ per cent of them were rotted by blue mold.

THE SECOND TEST IN WASHINGTON.

In order to get an idea of any change that might occur in the percentage of decay as the season advances and to study further the effect of refrigeration as a preventive of rot, another test was begun on March 28. Mr. Leslie Pierce, who was supervising some spraying work on the prevention of melanose in Florida, picked and sent to Washington, D. C., from Orlando, Fla., melanosed, ammoniated, and bright oranges to be used in the experiment.

In this case some of the fruits were sprayed with the spores of the common citrus blue mold, *Penicillium italicum*, and others with a dark olivaceous species also found on oranges and which appears to be *Penicillium olivaceum*. But owing to the fact that the application of mold spores seems to have had so little effect the two fungi are not distinguished in the records as given in experiment 2 of Table I.

The data in this second experiment are again rather surprising, both in regard to the relative numbers of oranges decayed by *Phomopsis citri* and by mold and in regard to the effects of only moderately low temperature in checking or preventing the decay. Of 30 fruits sprayed with spores and held at room temperature, 14 decayed; 13 of them, or 92 $\frac{2}{7}$ per cent, were decayed by *Phomopsis citri*, and only 7 $\frac{1}{7}$ per cent by *Penicillium*. Only 5 of the total 17 held in a refrigerator had been treated with mold spores; 1 of the 5, or 20 per cent, had a very slight indication of decay at the stem end. This

would tend to strengthen the evidence afforded by the former experiment in making it appear worth while to precool oranges for transportation when they are taken from groves which yield a high percentage of decay.

SUMMARY AND CONCLUSIONS.

These preliminary experiments are too small and few to permit any but tentative conclusions, yet the results are so clear cut and uniform in regard to some of the significant points that they may be specially noted. In the first place, it should be borne in mind that the condition of the fruit at maturity is a resultant of the environment of the grove during the growing season. Coincident with the uncommonly wet season of 1912 melanose and ammoniation of the fruit were prevalent over most of the citrus region of Florida, and it is very probable that the wet weather was directly related to the occurrence of such rind injuries. The excessive moisture of both the soil and the air in connection with these injuries resulted in numerous splits and rind distentions, which caused an enormous development of mold in the groves. The presence of large numbers of stinkbugs, which suck juice from oranges, probably also added to the epidemic by inoculating sound fruits when inserting their beaks through portions of rinds on which the air currents had deposited mold spores. The rather muggy warm weather prevailing in late November and in December doubtless also contributed to the heavy decay of that time, for these experiments indicate that temperatures no lower than 15° C. (60° F.) practically prevent the development of the mold rot.

But in addition to the mold-rot epidemic induced by the split and cracked rinds, much fruit dropped and decayed which was not split. The above results make it appear probable that *Phomopsis citri* was responsible for most of the rot of that type except what was due to bug-puncture infections. This also agrees with the fact that melanose was very abundant in the districts where much fruit decayed. However, the scarcity of phomopsis pustules on the dead twigs during late fall and winter argues that this fungus may sporulate elsewhere or that its mycelium persists in some melanose spots on the stem or calyx of the fruit.

Perhaps the most important conclusion that these observations force upon us is the importance of growing fruit that is free from melanose and thus not only obviating a reduction in the market value of the fruit but also preventing some splits and most of the stem-end rot. The fact that the refrigerator temperature used in these experiments practically prevented all decay suggests that shipping tests should be made with precooled fruit in refrigerator cars and boats.

THE WILD PROTOTYPE OF THE COWPEA.¹By CHARLES V. PIPER, *Agrostologist, in Charge of Forage-Crop Investigations.*

In a recent bulletin the writer has given an extended account of the cultivated forms of *Vigna* known as cowpeas, catjangs, and asparagus beans, all the data and conclusions being based on cultivated material.² In that bulletin the three were considered different species, namely, *Vigna sinensis*, *V. catjang*, and *V. sesquipedalis*, but it is pointed out that all can be crossed readily and that a perfect series of intergrades exists in respect to all characters.

In a previous bulletin Mr. W. F. Wight³ has gone into great detail into the early history of this same group, reaching the conclusion that they represent three distinct species and—

That both *Vigna sinensis* and *V. catjang* originally came from the region including and extending from India to Persia and the southern part of the Trans-Caspian district, and that the Persians called one or both of them by the name "lubia" and applied that name to *V. sinensis* in northwest India after their conquest of that region. The cultivation of *V. sinensis* extended to China at a very early date, but the distribution of at least one of the species with the name "lubia" has extended from the region of its origin at the beginning of the Christian Era to Arabia and Asia Minor and had reached some of the Mediterranean countries of Europe at about the same time, but did not become known in Central Europe until the middle of the sixteenth century.

One difficulty in accepting Wight's conclusion as to the original habitat of the cowpea is the fact that no wild plant is known in the region indicated that could in any likelihood be the wild prototype. This difficulty is, however, paralleled by a similar one in the case of maize, kidney bean, and other plants cultivated from remote antiquity. Still earlier the subject had been discussed by Körnicke,⁴ who reached the conclusion that all the cultivated forms known as cowpeas, catjangs, and asparagus beans represent but one botanical species, *Vigna sinensis*, whose native habitat he believed to be central Africa. He based this opinion on specimens collected by Schweinfurth, by Schimper, and by Kotschy, but enters into no botanical discussion regarding the identity of the wild with the

¹ Issued May 3, 1913.

² Piper, C. V. Agricultural varieties of the cowpea and immediately related species. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 229, 160 p., 12 pl., 1912.

³ Wight, W. F. The history of the cowpea and its introduction into America. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 102, pt. 6, p. 59, 1907.

⁴ Körnicke [Ueber von Apotheker Winter bei Gerolstein aufgefundenene neue und seltenere Pflanzen.] Verhandlungen, Naturhistorischer Verein der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück, Jahrg. 42 (F. 5, Jahrg. 2), Correspondenzblatt 2, p. 136-153, 1885.

cultivated plant. Indeed, it is not clear that he examined the actual specimens, as he writes, "I predict that the wild forms are slender and twining and bear pods which, when ripe, spring open." (Translation.)

A recent opportunity to study the *Vigna* material in the Berlin, Kew, and British Museum herbaria and the study of the wild African plant under cultivation has led to the conviction that Körnicke's conclusion regarding the native plant of Africa being the wild form of the cultivated cowpea is correct. The wild species itself is quite variable, and its relationship to other supposedly distinct species is not clear. Until these supposed distinct species are also studied under cultivation there must remain some doubt as to their actual affinity. From herbarium studies the following facts are adduced and conclusions offered:

Southward from the Sahara Desert and extending across the continent is a wild plant that differs from most cultivated catjangs only in the following characters, viz: The leaflets are minutely scabrous on the upper surface and the petiolules are usually pubescent; the small pods are dark colored, scabrous, 7 to 8 centimeters long, and in dehiscence the valves coil tightly. In herbaria this plant is usually labeled either *Vigna sinensis* or *Vigna nilotica*, and on one of Schweinfurth's sheets the name *Vigna spontanea* is written.

The numerous collections of this plant include specimens from Egypt, Nubia, Kordofan, Abyssinia, German East Africa, Zanzibar, Senegal, Gold Coast, Kamerun, Nigeria, Angola, Rhodesia, Natal, and Madagascar. It is sometimes cultivated, as indicated by Schweinfurth's No. 1778 collected between Debenhuch and Kenek, Egypt, and No. 888 from Khartum. Lederman also found it cultivated at Garua, Kamerun, as shown by his specimen No. 5149a. Stuhlman's collections in Zanzibar give the native name as "kunde" or "kunde ya muita," and state that the wild bean is not eaten. The name "kunde" is, however, generally applied to the cultivated cowpea in German East Africa, or, according to Braun,¹ the seeds are called "kunde" and the plants "mkunde."

In northern Nigeria the wild plant is called "gayan-gayan" and seeds from specimens collected in Sokoto, Northern Nigeria, by Dr. J. M. Dalziel (No. 318, October, 1910), germinated freely and grew in a greenhouse in Washington. The nearly black scabrous pods are about 10 centimeters long. The seeds are 5 millimeters long, buff, marbled with brown, speckled with minute blue dots, and have a few black blotches. Mr. George W. Oliver has already crossed this plant with various varieties of cowpeas. Prof. W. J. Spillman hazards the prediction that the wild plant contains in its seed colors all the

¹ Braun, K. Bestimmungstabellen für die Eingeborenenkulturen von Deutsch Ost-Afrika. Der Pflanze, Jahrg. 7, No. 8, p. 440, 1911.

color factors found in the numerous cultivated varieties, except perhaps the "eye." The hybrids above mentioned have been made partly with the idea of clearing up this point.

The numerous cultivated forms of *Vigna* in Africa are mostly true cowpeas, and about 40 varieties from Egypt, Sudan, Rhodesia, Transvaal, British East Africa, and German East Africa have been grown in comparative trials and are described in Bulletin 229 already cited. In Angola occur cowpeas distinguished by having more or less retrorse pubescence, especially on the stem. These have not been grown in our trials, but excellent botanical material was collected by Welwitsch, who considered the plant a distinct species, *Vigna macundi*. Except for the small amount of pubescence, however, there is nothing to distinguish it from an ordinary cowpea, Welwitsch¹ speaks of it as commonly cultivated and occasionally spontaneous. About Golungo Alto, Angola, the native name is "macundi" (plural) and "licundi" (singular) both suggestive of "kunde," the native name of the cowpea in German East Africa.

The asparagus bean apparently is rare in Africa, only one lot, S. P. I. No. 11091, from Abyssinia, having been secured.

The catjang is not infrequent in Africa. In Bulletin 229 four varieties from Abyssinia are described, and Schimper found it abundantly cultivated near Humboldt Springs, Djur Land, Anglo-Egyptian Sudan. From the wild cowpea the catjang differs mainly in having the pods pale and smooth instead of dark and scabrous, but all intergrades occur. A form with pale, scabrous pods was collected by Ehrenberg in cultivation at Gurfuda [Kurfuda], Arabia. In all probability this is the same as the Egyptian plant named *Dolichos lubia* by Forskal, also described as having scabrous pods. Similar specimens have been collected in the Seychelles (I. Horn, No. 474, in 1874) and in Java (Surokarta, Horsfield). Such specimens also come from Meshra el Zaraf, Sudan, with the information: "Eaten by cattle; seeds eaten by natives during the year of drought; native name, 'Lubiet el Gazal.'"

Besides the above-mentioned plants, all of which are undoubtedly referable to *Vigna sinensis*, there occur in the southern half of Africa other forms where relationship to the cowpea is less clear.

The commonest of these is the plant known botanically as *Vigna triloba* Walpers, which differs from the wild cowpea mainly in its leaflets being almost always three lobed. Some of the labels indicate also that the plant is not a true annual, but from herbarium specimens this can not be determined. Unless there is a distinction in the matter of life period or duration, *Vigna triloba* can not be kept distinct from the wild form of *Vigna sinensis* by any character yet

¹ Hiern, W. P. Catalogue of the African plants collected by Dr. Friedrich Welwitsch in 1853-61, pt. I, London, 1896, p. 260.

pointed out. The lobing of the leaves is very variable and commonly occurs in cultivated *Vigna sinensis*, especially when in poor soil.

Vigna triloba occurs mainly south of the Equator, where it is apparently never cultivated. However, specimens collected by Dr. J. M. Dalziel in the Katagum District, Northern Nigeria, May, 1908, which seem indistinguishable from *Vigna triloba*, bear the legend "Common cultivated bean of the fields."

In Angola, forms of *Vigna triloba* with narrow leaflets occur. Such specimens are represented by Welwitsch's No. 2262 from Loanda and No. 2263 from Pungo Andongo. On the former of these Welwitsch has recorded "a herb persisting for several years but scarcely perennial," and on the latter "a herb enduring apparently for several years." Gossweiler has more recently made collections in the same region. His No. 4802 from Grongude, apparently identical with Welwitsch's No. 2262, is stated to be "a perennial many-leaved vine, with large blue flowers," while his No. 1534 from Penedo, quite the same as Welwitsch's No. 2263, bears the legend "a perennial climber."

Differing from this narrow-leaved plant mainly in being pubescent is a form occurring in Natal, Transvaal, etc., which was called *Scytalis protracta* by E. H. F. Meyer. All recent botanists¹ have considered this only a form of *Vigna triloba*.

Another form with still narrower leaflets and lacking the pubescence has been named *Vigna triloba stenophylla* Harvey and Sonder.¹

In the light of present evidence it is not clear that *Vigna triloba* is specifically distinct from the wild *Vigna sinensis* of Africa. On the other hand, the statements of Welwitsch and of Gossweiler that *Vigna triloba* persists more than one year indicate that it is different, in this respect at least, from *Vigna sinensis*. The trilobed leaflets as a mark of distinction can not be depended upon, yet in classifying specimens this is the only evident character. In the herbarium at Kew are specimens of both species, so far as this distinction may be depended upon, collected by Dr. J. M. Dalziel in the Katagum District, Northern Nigeria. The one referable to *Vigna triloba* is said to be "the common cultivated bean of the fields," while no data regarding the habitat of the other are recorded.

There is scarcely room for doubt, however, from the ample herbarium material, that the African plant with blackish scabrous pods and scabrous leaflets found wild over a great area and occasionally cultivated is the original wild form of our cultivated cowpea. This conclusion is further confirmed by a study of comparative cultures and the fact that hybrids between the wild plant and the cowpea are readily obtained. Whether *Vigna triloba* is to be considered a distinct species can hardly be decided in the light of present evidence.

¹ Harvey, W. H., and Sonder, O. W. Flora Capensis, v. 2, Dublin, 1861-2, p. 241.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 125.

WILLIAM A. TAYLOR, Chief of Bureau.

SUDAN GRASS, A NEW DROUGHT-RESISTANT HAY PLANT.

BY

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BUREAU OF PLANT INDUSTRY.

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[Cir. 125]

SUDAN GRASS, A NEW DROUGHT-RESISTANT HAY PLANT.

INTRODUCTION.

For several years past, beginning with 1906, the writer and his assistants made a careful study of Johnson grass with the view of finding a strain lacking the underground rootstocks which make Johnson grass so objectionable. While variations in this character were found, no single plant was detected which had the rootstocks wholly absent. Coincident with these studies packages of Johnson grass seed were obtained from various foreign sources, in part with the assistance of the Office of Foreign Seed and Plant Introduction. Among those received are two other varieties bearing rootstocks like Johnson grass but differing in other characters, and two very distinct varieties that have the rootstocks wholly absent. The first of the latter was received in 1909 under the name "garawi," through Mr. R. Hewison, Director of Agriculture and Lands of the Sudan Government at Khartum. After growing this for one season at Chillicothe, Tex., it was inventoried as Seed and Plant Introduction No. 25017.

In further correspondence with Mr. Hewison some additional information has been secured. The Sudan botanists were under the impression that garawi is a form of *Andropogon halepensis*, or Johnson grass. According to Mr. Hewison, the following note appears in Broun's Catalogue of Sudan Flowering Plants:

Andropogon halepensis Brot. Adder or Adra (wild variety) and Garawi (cultivated), Arab. Tall grass cultivated for fodder. The seeds are eaten in times of scarcity. When wild it grows to a height of 12 feet and is found in damp localities along the river banks or edges of pools. Found in Sennar, White Nile, and Kordofan.

Whether the wild plant is the same as the cultivated Mr. Hewison is not sure, and promised specimens have not yet been received. In Sudan, garawi is cultivated only to a limited extent, mainly at the experiment station and at military hay farms, two cuttings of hay being secured there each season under irrigation. The seed was brought to Sudan from Egypt, where it is also cultivated to some extent under the same name. It is probable that it is the grass that all writers on Egyptian botany have called *Andropogon halepensis*.

The exact nativity of garawi is still a matter of doubt, nor is it clear that genuine *Andropogon halepensis* occurs in the same region.

A few plants of garawi lived over the winter of 1911-12 at Gainesville, Fla., without, however, forming any rootstocks.

The second variety was received on December 2, 1909, from Dr. L. Trabut, Algiers, Algeria, and given S. P. I. No. 26301. Dr. Trabut's original notes are as follows:

This grass is vigorous but not stoloniferous and would be interesting for hybridization with sorghum. It is moderately good forage like Johnson grass, but has the advantage of not stooling (i. e., suckering). This variety is perennial here and produces many seeds.

Under the conditions in the United States this variety has behaved purely as an annual. In further correspondence with Dr. Trabut, he writes that he believes this grass to be common in Africa and that he has received it from the arid regions between Algiers and Senegal.

The two varieties are quite distinct from each other and the name "Sudan grass" has been given to S. P. I. No. 25017 and "Tunis grass" to S. P. I. No. 26301. Botanically, they are both to be considered varieties of *Andropogon sorghum* and not of *Andropogon halepensis*, as the three known varieties of the latter all have vigorous underground rootstocks. Trials at numerous places have demonstrated that Sudan grass promises high value for hay, especially in the semiarid regions where no perennial grass has thus far been found suited to the conditions. Indeed, it is not too much to predict that it is there destined to become the leading grass for hay production. Under more humid conditions Sudan grass has also succeeded admirably and it will probably replace the foxtail millets to a large extent, as it produces better hay and usually larger yields. Tunis grass has not as yet been widely tested, owing to lack of seed. It is slower in starting growth and less tall than Sudan grass. As it shatters its seed very readily it is likely to be of only limited usefulness unless this character can be changed.

Sudan grass has been tested most carefully in Texas (fig. 1) and at Arlington Farm, Virginia, but at least one year's trial has been made at many places in the Great Plains and at various agricultural experiment stations. There is still much to be learned in regard to the crop, but the data at hand indicate approximately the best methods of culture. Sudan grass is a sorghum and requires practically the same temperature conditions as that crop. It is, however, earlier than any sorghum yet known and will probably mature in Montana and North Dakota, as it ripened seed in 1912 at Brookings, S. Dak.

Individual plants of Sudan grass under favorable conditions will attain a height of 8 to 10 feet and may possess 20 or more stalks to a plant. The stems seldom become larger than a lead pencil, even

in the largest plants. Broadcasted or drilled the height averages 3 to 4 feet, and the stems are much finer. The stems are mostly unbranched, strictly erect, and decidedly leafy, very much more so than Johnson grass. The sugar content is small, but enough to give a decided sweetish taste. The flower cluster is loose and open, pyramidal in form, and 6 to 12 inches long. There is practically no shattering of the seed at maturity.

SEEDING SUDAN GRASS.

Sudan grass may be sown broadcast, drilled, or in cultivated rows. Where there is sufficient moisture, broadcasting or drilling is prefer-

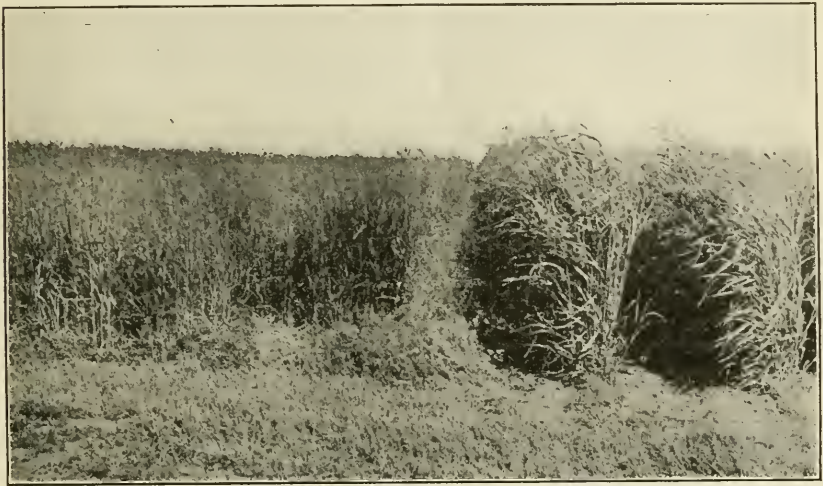


FIG. 1.—Fields of Sudan grass at Dalhart, Tex. On the right, uncultivated rows; on the left, broadcasted.

able; otherwise the grass is likely to be coarse. In seeding this way 3 pecks of seed to the acre should be used.

Under conditions of light rainfall Sudan grass is probably best sown in cultivated rows, though excellent results have been secured in dry regions from broadcasting. In rows 36 inches wide, 4 pounds of seed to the acre are sufficient, even with rather thick seeding, which is recommended when grown for hay. For seed production much thinner seeding has given excellent results.

It is sometimes practicable in humid regions to sow in 18-inch rows and cultivate. This is especially desirable where the land is very weedy. The grass grown under such conditions does not become too coarse, and, furthermore, the dense shade kills out the weeds. Five pounds of seed to the acre should be used when thus sown.

FEEDING VALUE OF SUDAN GRASS.

All reports agree on the high palatability of Sudan grass, either green or cured. At Chillicothe, Tex., the farm horses even ate readily the straw from which the seed had been thrashed. Until feeding experiments can be conducted no definite statement of the comparative feeding value of this grass can be made.

Table I shows the analyses of a series of hay samples cut at various dates at Arlington Farm, Virginia, in 1912. Perhaps the most interesting feature shown is the close comparison of the mature straw with hay cut at earlier stages.

TABLE I.—*Analyses of Sudan grass grown at Arlington Farm, Virginia, in 1912, cut at various dates in different stages of maturity.*

Substance.	Cut Aug. 7.				Cut Sept. 1, before heading.	Cut Oct. 1; seed was fully mature.
	Before heading.	Heads just appearing.	Just beginning to bloom.	In full bloom.		
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Moisture.....	4.13	3.54	3.46	3.51	4.82	4.38
Ash.....	6.61	5.55	5.02	5.64	7.12	5.59
Ether extract.....	1.72	1.39	1.23	1.27	1.49	1.48
Protein.....	7.75	6.06	5.16	4.66	5.63	4.19
Crude fiber.....	30.68	31.94	33.23	35.12	34.30	34.44
Pentosans.....	21.82	24.01	24.70	24.51	23.38	26.70
Undetermined.....	27.29	27.51	27.20	24.79	23.26	26.70

EXPERIMENTAL TRIALS WITH SUDAN GRASS.

Owing to the fact that Sudan grass came from a dry tropical country and that the quantity of available seed was very small, the preliminary tests were all made in Texas. The remarkable adaptation of the grass to Texas conditions led to its being tested in 1911 at Arlington Farm, Virginia, and in various Southern States. At the former place it succeeded beyond expectation, so that seed of it was sent in the spring of 1912 to many experiment stations with the request that it be tried, but for various reasons comparatively few stations made a test. The reports of these trials are given later in this circular. As most of these tests were very small the results can only be regarded as indications of its possible value. In most cases the grass was seeded in cultivated rows, under which condition it is usually too coarse for hay of high quality. By thick planting, however, this difficulty is easily overcome.

Practically every test of the grass made in the semiarid regions from South Dakota to Texas has given remarkably favorable results. There is scarcely room to doubt the very high value of the grass for this portion of the United States. A single test in eastern Oregon also gave very promising results, so the grass is doubtless adapted

to Columbia Basin conditions. Its wide adaptability to the climatic conditions of the United States east of the Rocky Mountains is noteworthy. While the original stock showed little variability, the grass has crossed very readily with sorghums, so that it is possible to select various hybrids differing especially in leafiness and date of maturity. Presumably all of the variants are due to crossing, but no isolated areas of the original seed have yet been grown to determine whether other factors are operative.

In the humid regions the results are not so uniformly satisfactory, and the future of the grass east of the 100th meridian can not be forecasted with confidence until much further evidence is available.

A few packages of seed were also sent in 1911 and 1912 to farmers for practical trials. The reports of several of these trials are cited as indicative of the value of the grass, and some of them are valuable as suggesting critical experiments.

RESULTS OF TESTS AT CHILLICOTHE.

Sudan grass was first tested at Chillicothe, Tex., in 1909, a single row being grown and all the seed saved. In 1910 this seed was planted in 30-inch rows on seven-fifteenths of an acre of land. Though the season was exceedingly dry it grew to a height of 4 to 4½ feet. A small portion of the plat, one-fifteenth of an acre, was cut for hay and yielded two cuttings. From the remainder, 134 pounds of seed were secured in two pickings, which is at the rate of 335 pounds per acre.

In 1911, plats were planted June 1 on newly broken sod land, from which two cuttings of hay were secured, each larger than the one cutting of German millet grown alongside. The total rainfall from April 1 to November 1 was 14 inches. The drought conditions of the season were such that both milo and kafir produced only about one-fourth of a normal grain yield.

During the season of 1912 more detailed results were secured. Four cuttings of hay were obtained from a one-tenth acre plat, drilled on April 26 at the rate of 3 pecks of seed per acre. The date and amount of each cutting are as follows:

	Pounds.
June 22-----	214
July 17-----	181
August 20-----	305
October 14-----	180
Total-----	880

This yield is at the rate of 4.4 tons per acre. During this period the rainfall was as follows:

	Inches.
April 26 to 30.....	0.68
May.....	.52
June.....	4.69
July.....	1.39
August.....	3.35
September.....	2.92
October 1 to 14.....	1.97
Total.....	15.52

Two acres were also planted on April 20 in rows 36 inches apart. This crop grew to an average height of 6 feet 4 inches and was harvested for seed on August 3, 96 days after planting. It was a little overripe and probably 10 per cent of the seed was lost by shattering. The actual seed saved from the 2 acres was 708 pounds. By September 20 the grass was again about 18 inches high and beginning to head, when it was cut for hay in order to plow the ground. The yield was estimated at about 1,000 pounds per acre, but it was not weighed, owing to rainy weather.

Two fields of Sudan grass were grown for seed under contract with two farmers in the immediate neighborhood of Chillicothe. One farmer planted 12 pounds of seed on 13 acres in 42-inch rows and secured a yield of about 10 bushels per acre. The second farmer planted 4 pounds of seed on 2 acres in 42-inch rows and harvested 1,285 pounds of clean seed, or 15.3 bushels per acre.

The seed grown on the experiment farm weighed 40 pounds to the bushel; that grown by the first-mentioned farmer, 44 pounds, and by the second, 42 pounds per bushel. In contrast the seed grown on the experiment farm in 1911 weighed but 32 pounds per bushel.

RESULTS OF TESTS AT ARLINGTON FARM.

At Arlington Farm, Virginia, Sudan grass was tested in 1912, both broadcasted and in 18-inch rows (figs. 2, 3, and 4). The broadcasted plats were sown on June 3 at the rate of 10 pounds of seed to the acre. The broadcasted stand was not perfect, some comparatively sterile spots being almost bare of Sudan grass and occupied by pigeon grass. The crop in these plats grew to an average height of 5 feet. One twentieth-acre plat cut for hay on August 23 yielded 280 pounds, or at the rate of 2.8 tons per acre. The second growth on this plat was 30 inches high and was beginning to head on September 20. This grew to a height of about 3 feet, but the seed was not mature when killed by frost on November 4. Nine plats of one-twentieth of an acre each were cut for seed on September 20 and yielded, on the

average, 6 pounds, or 3.3 bushels per acre, only one-fourth of the quantity secured from the plats in rows.



FIG. 2.—A broadcasted field of Sudan grass at Arlington Farm, Virginia, 1912.

Eight plats of one-twentieth of an acre each were planted in 18-inch rows on June 3 at the rate of 5 pounds seed per acre and culti-



FIG. 3.—Rows of Sudan grass at Arlington Farm, Virginia, 1912. Each row is grown from the seed of a single plant. The three rows on the right are typical Sudan grass.

vated twice. Two of these plats cut on August 23 when fully headed and about 7 feet high yielded, respectively, 284 and 347 pounds per plat, or at the rate of 2.8 and 3.5 tons to the acre. This could have

been cut as early as August 10 with a very slightly smaller yield. The second growth on these two plats was over 3 feet high when killed by frost on November 4.

The remaining 8 plats were harvested for seed on September 20 and yielded an average of 23 pounds each, or 460 pounds per acre. Practically no seed was lost by shattering. The second growth in these plats was about 1 foot high when killed by frost on November 4.

A late seeding was made on August 7 in rows, and this was 48 inches high and fully headed when killed by frost on November 4.

There can be no doubt that by seeding not later than June 1 two full cuttings of Sudan grass for hay can be obtained each season in

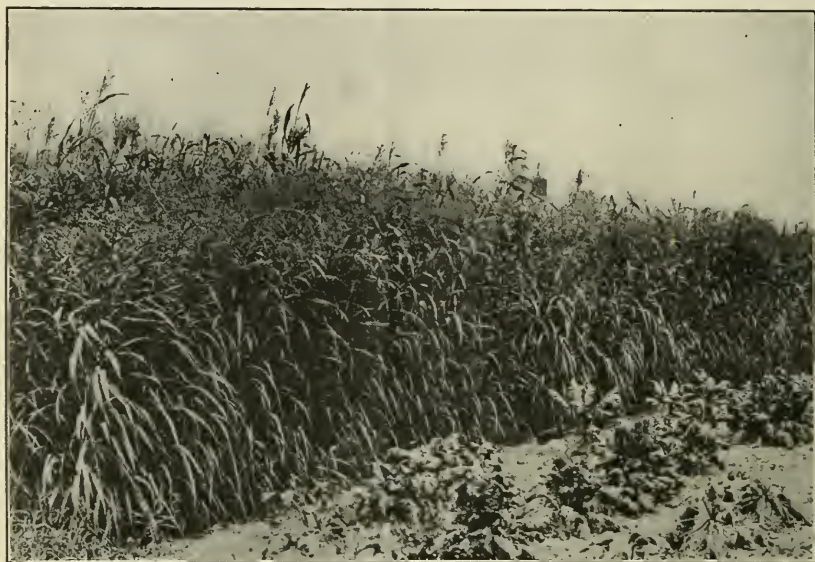


FIG. 4.—Sudan grass at Arlington Farm, Virginia, 1912. This is another view of the right-hand row shown in figure 3. The tall plants in the background are hybrids between Sudan grass and some variety of sorghum.

Virginia. The grass has shown much stronger growth in cultivated rows than when broadcasted, but it still remains to be determined which method is most desirable.

The seed grown at Arlington Farm in 1912 weighed 36 pounds per bushel.

Mixtures of Sudan grass with cowpeas and with soy beans were also tested (fig. 5). A one-tenth acre plat was broadcasted on June 11 with 3 pounds of Early Black cowpeas and 2 pounds of Sudan grass. This was cut for hay on September 6 when the Sudan grass was in bloom and the first pods of the cowpeas were fully grown. The grass was 6 to 8 feet high and the cowpea vines were of about an equal length. The plat yielded 925 pounds of cured hay, about one-

fourth being cowpeas. This is at the rate of 4.6 tons of the mixture per acre.

In an adjacent one-tenth acre plat Johnson grass and cowpeas were seeded at the same rate; that is, 2 pounds of Johnson grass and 3 pounds of Early Black cowpeas in place of Sudan grass (fig. 5). The yield of the mixture was 561 pounds of air-dry hay, or 2.8 tons per acre.

A similar mixture of Sudan grass and Arlington soy beans, a twining variety, was sown the same date, using 3 pounds of soy beans and 2 pounds of Sudan grass. About one-fourth of the mixture was soy beans, which twined about the grass to a height of 4 to 6 feet. When



FIG. 5.—Plats at Arlington Farm, Virginia, showing mixtures of Sudan grass and cowpeas (right) and Johnson grass and cowpeas (left).

cut on September 6 the Sudan grass was in bloom and the soy-bean pods were about half grown.

This mixture cured more readily than the cowpea mixture and was superior in physical quality. The yield was 888 pounds of cured hay, or at the rate of 4.4 tons per acre.

Figure 6 shows a stand of Tunis grass planted in rows at Arlington Farm for comparison with the Sudan grass shown in figure 3.

TESTS AT MISCELLANEOUS EXPERIMENT STATIONS.

TEXAS.

At the San Antonio (Tex.) Field Station Mr. S. H. Hastings tested Sudan grass in 1911 and 1912 and reported as follows:

From the growth of the plat tested in 1911 this appears to be the most promising grass that has been grown at the experiment farm. Two plats were

planted, one where it could be irrigated and the other without irrigation. The plat not irrigated made a good growth and proved to be as drought resistant as Johnson grass, although the plat was so small that the yield would not be reliable. Only one cutting was secured from this planting. Both plats were planted on March 31—somewhat later than is necessary. The first cutting of the irrigated plat was on July 31 and gave a yield at the rate of 3.49 tons per acre and a seed yield of at least 506 pounds per acre. The second cutting was made on October 10 and gave a yield of 3.11 tons per acre, making a total for the season of 6.60 tons per acre. At least three cuttings would have been secured had it been seeded earlier and the first cutting not allowed to seed, which would have increased the yield materially.

In 1912 we put in a planting of Sudan grass March 15, without irrigation, and the yield from two cuttings was 5.66 tons per acre. Sorghum planted under the same conditions gave a yield of 4.68 tons.

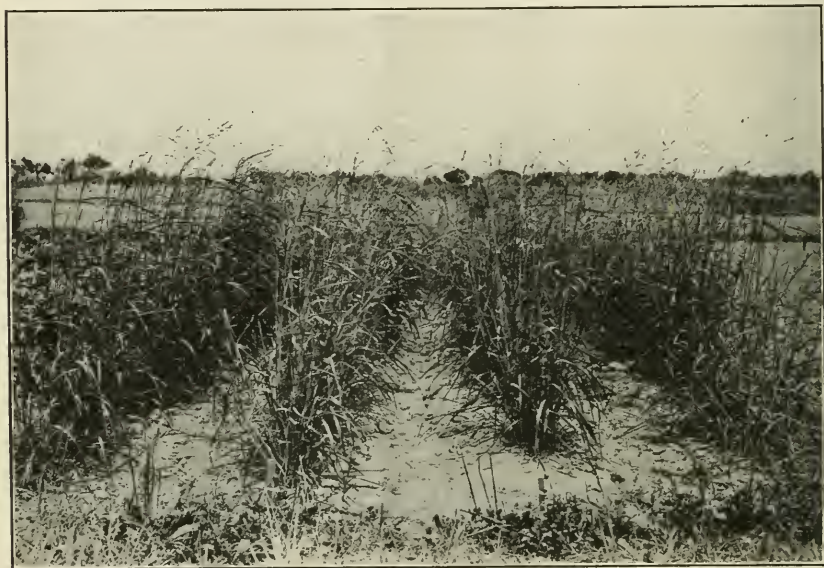


FIG. 6.—Rows of Tunis grass at Arlington Farm, Virginia, 1912. Note the very much thinner appearance of this grass as compared with the Sudan grass in figure 3.

At College Station, Tex., a test was made in 1912 by Mr. A. B. Conner, who sent in the following report:

Planted May 15 on one-fifth acre plat in rows 3 feet apart. Germination was fairly good, but stand not as uniform as desirable. Grass made very vigorous growth up to July 1. On July 7 was just coming into full boot. On July 15 it was in full head at a height of 7 feet and presented a very vigorous appearance. On August 8 the plat averaged 7 feet in height, and on account of the irregular stand each plant had put out a number of culms. Some were noted with as many as 40 to 50. Plants were very leafy to the top, showing superiority in this respect to Johnson grass. Harvested August 14 for seed and gave a yield of 57 pounds of thrashed seed. A second growth, which was produced without any rainfall, the season being exceptionally dry and not enough rain to produce a second growth on sorghums, attained a height of above 5 feet and

was harvested for seed October 23, yielding only 8 pounds. The total yield of seed from the one-fifth acre plat was 65 pounds, or at the rate of 325 pounds per acre. Seed tested 19 pounds per bushel, which gave the equivalent of 17+ bushels per acre.

A test at Dalhart, Tex., gave very promising results, thus reported by Mr. W. D. Griggs:

Two one-tenth acre plats of Sudan grass, one broadcast and one in rows, were seeded May 2, 1912 (fig. 1). The plat in rows failed to give a good stand and it was reseeded May 21. It was intended that these plats be harvested for hay, but owing to the local demand for seed among farmers it was decided to let the grass mature and harvest it for seed. Both plats were harvested September 7 and gave a total yield as follows: Broadcast, 545 pounds; in rows, 552 pounds of hay per plat. The former yielded 46 pounds of seed; the latter, 54 pounds. It is estimated that 25 per cent of the seed was lost in harvesting.

CALIFORNIA.

The following is a report on a trial at the Plant Introduction Field Station, Chico, Cal., by Mr. Roland McKee:

Two rows of Sudan grass, one 75 feet long and the other 150 feet long, were grown at Chico in 1912. It was grown on good loam soil and given irrigation. A fine growth was made, and without question this is the most promising grass for growing under irrigation in the Sacramento Valley that has yet been tried. The number of cuttings of hay that it is possible to secure was not determined, as with both the plantings a seed crop was allowed to mature, but it seems probable that three good cuttings of hay can be made. One of the plantings was allowed to produce a seed crop from the first growth. This was harvested late, but still a good hay crop was produced after that date. The other planting was cut for hay shortly after it came into bloom. A good crop of hay was secured and after that date a seed crop was matured.

The following data give some idea of the growth of this crop:

May 2-----	Row 75 feet long; sown.
July 9-----	In full bloom and 48 to 72 inches high.
July 15-----	Cut for hay.
August 29-----	Second growth 60 to 90 inches high.
November 1----	A good crop of seed was ripe.
May 13-----	Row 150 feet long; sown.
July 9-----	In first bloom and 36 to 40 inches high.
August 20-----	First seed ripe.
August 28-----	70 to 80 inches high.
September 14--	Cut for seed; 18 pounds secured. Yield about 40 bushels per acre figured on basis of 4-foot rows and 30 pounds of seed per bushel.
November 1----	Second growth 3 to 4 feet high.

SOUTH DAKOTA.

A small test made in 1912 at Brookings, S. Dak., is thus reported by Mr. Samuel Garver:

Three rows, 36 inches apart, each 8 rods long, were planted April 30. The grass grew very slowly during the cool spring, being only 3 or 4 inches high on June 10, and was not injured meantime by three or four frosts. At this time warm weather began and the grass grew rapidly, maturing its seed

September 16. The actual amount of seed harvested from the three rows was 18.5 pounds, which is at the rate of 678 pounds per acre.

June 12, two rows, 36 inches apart, each 8 rods long, were planted. One row was cut for hay September 16, when 6½ feet high, but it should have been cut earlier. The yield of this row was 110.5 pounds, or at the rate of 6.08 tons per acre. The second row was left for seed, but did not fully mature when killed by frost September 18, only 2 pounds of mature seed being secured.

OREGON.

Regarding a test at the cereal station, Moro, Oreg., in 1912, Mr. D. E. Stephens gave his experience as follows:

Of the several grasses planted this spring at this station, the Sudan grass is the only one that gave good results. It was planted in rows 3½ feet apart. An excellent stand resulted and it grew vigorously to a height of 4½ feet. It was cut for hay on September 26 and yielded at the rate of 1.08 tons per acre. Although we have but this one year's results with this grass, it is the most promising one we have tried, with the possible exception of slender wheat-grass. So far as moisture is concerned, this season was a favorable one, but if this grass can stand the usual dry weather of this locality there is a future for it here.

MINNESOTA.

At the Minnesota Agricultural Experiment Station Prof. A. C. Arny reported that Sudan grass was planted in two short rows, one 8 feet long, the other 6, the rows 2 feet apart.

It was apparently sown thicker than it need be, for the grass is very thick in the rows and grew to an average height of 58 inches. There is a great abundance of leaves at the bottom. The stems are not very coarse and it looks as though the grass might make a very good quality of hay. The cattle seem to like it green and there is apparently no reason why they should not like it cured. It is altogether probable that, cutting the crop at the right time after planting it early in the season, two crops could be secured. The new growth at the base of the roots makes me think that this would probably be the way it would turn out.

I am not sure whether the grass will mature seed this fall or not. It depends altogether on how the frost holds off.

A few of the seeds were planted much thinner and they have reached a height of over 100 inches, being higher than any of our sorghum plants. Sown thin this way the stalk is quite coarse and it would not do for hay; that, of course, is not the way it is meant to be grown.

WISCONSIN.

From the Wisconsin Agricultural Experiment Station, Prof. A. L. Stone wrote as follows:

The Sudan grass sent us last spring for trial came a little too late to give us an opportunity to get in as large a plot of it as we would have liked to do. We put in only a single row of the grass, this row being about 60 feet long. The grass came on very nicely and headed out in fine shape. It will be impossible under the circumstances to make any estimate of the yield per acre, but from its appearance I am of the opinion this grass might prove of value in some sections of the country and possibly right here in Wisconsin, although it would need some experimentation to determine whether it can compete with timothy. I like the appearance of the grass.

INDIANA.

At the Indiana Agricultural Experiment Station Sudan grass was not a success, as is shown by the report of Mr. M. L. Fisher.

To say it plainly, I think Sudan grass is not worth the room it takes; at least such is its merit this present year. It has been a wet season and, of course, it could not show drought-resisting qualities. It is not at all equal to millet or sorghum. The plants which I have grown this year are not over 30 inches tall and never appeared to be very thrifty. I raised some Johnson grass some few years ago and the Sudan grass seems to be about the same for this section as the Johnson grass. I think the plant would not furnish two cuttings in this section, although I have not made an effort to determine that point.

OHIO.

At the Ohio Agricultural Experiment Station Sudan grass was tested in comparison with millets and sorghums. Prof. C. G. Williams gave the results as follows:

The yield of the Sudan grass and a few competitors are as follows:

	Tons, air-dry weight.
Sudan grass	3.88
Hungarian millet	2.25
German millet	3.55
Japan barnyard millet	4.48
Early Amber sorghum	8.75

We did not get a chance to test them out under droughty conditions, for we had anything but a drought this season. I am not able to give any opinion as to its ability to furnish two crops, as we did not cut it early for a second crop. You see that it compared very favorably with the millets. We have not tested it as to quality or palatability.

LOUISIANA.

Prof. W. R. Dodson, of the Louisiana State Experiment Station, tested Sudan grass in 1912 and reported as follows:

Two rows, each 300 feet long, were planted at the experiment station at Baton Rouge. The first cutting was made when the grass was 5 to 6 feet high; the second, August 26, when 4 to 5 feet high; and a third cutting was expected. The grass was cut each time when it was heading out.

Prof. Dodson estimates the first crop at 3 tons per acre and the second at 2 tons. A portion of the row left to mature failed to produce seed, doubtless owing to the work of the sorghum midge. In a later report the opinion is expressed that "we can safely count on two good cuttings and one moderate cutting."

OKLAHOMA.

For the Oklahoma Agricultural Experiment Station Mr. A. H. Wright reported as follows:

The Sudan grass grew well, reaching a height of 6 to 6½ feet in rows, maturing 8 to 10 days earlier than any other sorghum. The plats were small, 2 rows

in one plat covering one twenty-fifth of an acre and 6 rows in another one twenty-fifth of an acre. These were sown May 1 and harvested for seed August 12, yielding, respectively, at the rate of 900 and 700 pounds of seed and 2,775 and 2,525 pounds of stover per acre.

ALABAMA.

In reference to a test at the Alabama Agricultural Experiment Station, Mr. E. F. Cauthen sent the following account:

The Sudan grass was planted June 15 and was mowed for hay on August 16. We planted it alone, in connection with cowpeas, in connection with Japanese millet, and in connection with German millet. The Japanese millet is too early for the grass. The German millet fits better with this grass for hay. The ordinary cowpea seems to be a little late as a combination crop.

The hay should have been cut about the 1st of August, but was left for the farmers attending the summer school to inspect.

I am inclosing a print showing the grass and cowpeas just before they were mowed. It looks to me that the Sudan grass will make a permanent hay crop for this section. I have one plat that I am saving for seed and will mow the other the second time if the grass gets sufficiently high.

TENNESSEE.

At the Tennessee Agricultural Experiment Station one-tenth of an acre was sown broadcast. Prof. C. A. Mooers wrote as follows:

Our test with Sudan grass will not allow me to draw all the conclusions that you want. This grass rusted rather badly this year but made a fair yield, and under favorable conditions I feel sure that a second crop could be cut to advantage. It stood the dry weather only fairly well.

Comments by Prof. Morgan and others who saw the plats are rather unfavorable to this grass, but I think the tonnage was greater than that of millet sown at the same time. Of course, common sorghum would outyield it greatly, but the difficulty with which it is cured hardly enables us to make a fair comparison between the two. I may add that some Rhodes grass planted at the same time far outyielded the Sudan grass and made a very attractive growth, indeed.

KENTUCKY.

In a small test at the Kentucky Agricultural Experiment Station the grass was allowed to mature for seed. Prof. H. Garman reported the following results:

Land plowed, disked, and harrowed. One-fortieth of an acre planted at rate of 26 pounds per acre. Drilled; rows 3 feet apart. Came up May 27, 1912. Stand perfect. Began to bloom July 15. In full bloom July 25. Last bloom August 5. Cut for hay October 24. Yield, fresh, 190 pounds. Yield, dry, 184 pounds. Height of plants, 75 inches. Seed saved for planting in 1913.

MARYLAND.

The results obtained at the Maryland Agricultural Experiment Station are thus reported by Mr. Nicholas Schmitz:

The Sudan grass was planted in rows on June 3 and July 13. The planting made on June 3 consisted of about one-fourth of an acre. It came up well, and there was a good stand to begin with, but owing to various accidents during the season there was not more than about one-third of a stand left to produce

seed. The yield of seed was about 3 bushels and was harvested the first week in November.

That planted on July 13 did not mature seed before frost, but was ready for cutting for hay after the middle of October.

The grass seems very promising for this section, and it appears from the late seeding that over a large part of Maryland it would be possible to sow the grass after wheat and harvest a crop of hay that year.

The hay was relished very much by our dairy cows, and our dairymen were so enthusiastic over it that they asked for a field of this for hay for the cows next year.

VIRGINIA.

At the Virginia Agricultural Experiment Station a small test gave the following data:

The Sudan grass was broadcasted on a plat of one-fiftieth of an acre, but was not harvested until nearly mature (September 11), when it was $8\frac{1}{2}$ feet tall. The plat yielded 200 pounds of coarse hay, or at the rate of 5 tons per acre. The chief criticism offered as a hay plant is its coarseness.

NEW JERSEY.

From the New Jersey Agricultural Experiment Station Director J. G. Lipman sent the following report:

The Sudan grass was seeded in the spring, and the seeding was followed by decidedly unfavorable weather conditions. We had a severe drought in June and July. Nevertheless, the crop in question made fairly satisfactory growth and yielded on poor land a crop equivalent to 1 ton of dry matter per acre. The hay made from the Sudan grass was better in quality than that we could have made from millet grown under the same conditions. It is Mr. Owen's opinion that on the whole Sudan grass will compare favorably with millet as to growth under trying climatic and soil conditions and that it will produce a hay of better quality. It is my impression that on better soil and under more favorable climatic conditions Sudan grass should yield a crop equivalent to 2 or even more tons of hay per acre.

REPORTS OF EXPERIMENTAL TRIALS BY FARMERS.

TEXAS.

A detailed report of particular interest was received from Mr. F. J. McCarthy, Boerne, Tex., under date of September 4, 1912:

I deferred planting the seed. Seeing no sign of rain on April 18 and knowing there was not enough moisture in the soil to sprout the seed, I thought it best to plant the seed in the dust and take my chances of the first rain sprouting the seed. I had plowed a piece of new land in November, 1911. This land had received two harrowings; one December 10, 1911, the other February 14, 1912. This land is dry upland and was covered with a heavy growth of post oak, blackjack, and live-oak timber. April 18, 1912, I opened seven furrows, 100 yards long, 3 feet apart, and 2 inches deep. I planted the Sudan grass seed in furrows and covered the seed 2 inches deep with the dry dust. April 25 we had a drizzling rain which lasted from 8 a. m. until 10.30 a. m. May 1 the grass appeared above ground, about half of a stand. On investigation I found the other half of the seed dry and untouched by the moisture. May 4 we had a light rain, lasting from 6 a. m. to 7 a. m., not enough to sprout the dry seed.

We cultivated the Sudan grass with a 5-tooth cultivator, very shallow the first time, May 25. Second cultivation, June 6. Light rain, not enough to sprout the dry seed still in the ground. June 20, cultivated the third time with 5-tooth cultivator, shallow. July 1, cultivated the grass the fourth and the last time.

Being anxious to save the seed of this grass and thinking that every day would bring a rain to mature the seed I left it growing till August 18. On that date the grass was 8 feet 6 inches high and so dense was the growth one could not pass between the 3-foot rows.

I wish to state that on the same date, on the same land, and under the very same conditions, I planted kafir corn, milo maize, sorghum, and corn. All of these completely died out; they could not withstand the terrible heat and drought. The thermometer registered from June 1 to the date of this report (September 4, 1912) 105° to 110° F. in the shade. All vegetation was sear and dead except Johnson grass, which grew from 1 foot to 18 inches high. Sudan grass showed no effects of the drought except the seed heads, which remained white.

I do not know how far north this grass will grow, but I am satisfied there is no place too hot or dry for it if there is moisture enough to sprout the seed.

I am a stockman and I have been testing grasses and clovers for the last 35 years, with the result that I had to fall back on the sorghums, the very thing I was trying to avoid.

Additional data were supplied in a supplemental report dated January 24, 1913.

I herewith send you a supplemental report on the Sudan grass. The grass was first cut on August 14, 1912. It made a large amount of feed, I would say at the rate of 4 tons per acre.

A few days after being cut it began to grow from the stubble. Having no rain it grew slowly until September 21, 1912. On that date we had our first rain since June, 1912. After that date it began to grow quickly until November 6, 1912. November 1, 2, and 3 we had a severe frost which did not seem to hurt it at all. November 6, a dry blizzard came down on us. Being afraid I was going to lose the grass, I cut it and tied it, still green, in bundles and hauled it to the barn, where it cured and made me plenty of fine feed, it being 4 feet high at the time of cutting. If I had cut this at the proper time to make good feed, i. e., when the seed was in the boot, I could have cut it four times instead of twice, but I was anxious to save the seed. The terrible drought blasted the first crop and the frost prevented the second from maturing.¹ I exhibited at the Boerne fair, September 6 and 7, 1912, a bunch of this grass that measured 10½ feet high. Agents of the Agricultural Department, College Station, Tex., who acted as judges at the Boerne fair, were astonished. They told me they had the grass drilled just as I had drilled mine and it only grew 4 feet high for them.

Dr. W. O. Langdon, of Hutchins, Tex., grew Sudan grass in 1911 and again in 1912. He thus reported his 1912 results, under date of August 18:

The seed received this spring was planted in a little piece of ground in rows about 30 inches apart. It made a fine growth of an average of 6 feet. Much of it was nearly 8 feet high. When seed was ripe, about August 1, I cut it. It immediately began a second growth and is now nearly 3 feet high. The ground is covered with young plants from shattered seed. I think it is the greatest forage plant ever introduced into this section and that it will be worth millions to

¹ The blasting of the seed referred to by Mr. McCarthy is perhaps due to the work of the sorghum midge, which attacks Sudan grass, like other sorghums.

Texas and other semiarid sections. All stock eat it ravenously, as it is very sweet. The inclosed pictures will give you some idea of it, although it must be seen to be fully appreciated.

In a supplementary report dated January 20, 1913, he added:

In answer to your letter will inform you that the second growth of Sudan grass attained a height of at least an average of 6 feet. I cut and stored the hay from the first cutting, hoping to get the seed thrashed out, but did not succeed in doing so. I did not cut the second growth, but am sure it was as heavy as the first crop. I am sorry I can not give you more definite information as regards the amount of hay and seed produced, but have been very much "under the weather" for some months and so things have gone slack. Of one thing I am certain—there is no better forage plant for this section. It is a wonderful producer, very drought resistant, makes a most remarkably sweet-smelling hay with a very different odor from Johnson-grass hay, and will never become a pest.

Mr. J. R. Stegall, of Detroit, Tex., wrote concerning his 1912 experience as follows:

I sowed the Sudan seed that you sent me, half in bottom on strong land and the other half on sandy, thin land. The results on both are most wonderful. I prepared a good seed bed by breaking deep and then harrowed both ways. I sowed seed April 25, making the first cutting May 20. I have cut the twentieth of every summer month, June, July, and August. I am cutting to-day (August 20, 1912). The yield is larger every cutting, as it stools out from the root. The piece in the bottom I sowed by the side of a small spot of Johnson grass. I have cut the Johnson grass twice and the Sudan grass four times. Stock eat Sudan grass hay with more relish than Johnson grass hay, as the texture is not so coarse. This Sudan grass is the most wonderful thing in the way of hay I ever saw. I have had a great many applications for seed, but I have none to sell.

In a postscript Mr. Stegall added:

I neglected to mention we have had quite a long, dry time; no rainfall. Not all the crops were damaged. The Sudan grass has resisted the drought, the grass on the bottom land standing better than that on the sandy soil.

In a subsequent report additional data were given as follows:

You sent me 2 pounds of seed. I sowed it on one-eighth of an acre. I got 400 pounds of nice, cured hay at each cutting. Some of my neighbors told me I sowed it too thick, but for cutting in milk I am satisfied I sowed it about right. When I turned my cattle, hogs, and horses in the field, I had goobers, peas, corn, and crab-grass, but they would not eat any of these until the Sudan grass was completely consumed. Stock love it better than anything else they can get to eat.

I had a small patch of Johnson grass right by the side of the seed I sowed in the bottom. I cut the Johnson grass twice and the Sudan grass five times. The weather was dry and I got a nice cure every time I cut. Stock would eat the Sudan grass before they would the Johnson grass.

Mr. W. W. Price, Mount Pleasant, Tex., recorded his experience as follows:

On April 3 I sowed 5 pounds of Sudan-grass seed on one-half of an acre of light, sandy land. The grass reached a height of 7 feet and matured 64 days from the date sown, the cutting yielding $1\frac{1}{2}$ tons of hay.

The experience of Mr. H. N. Montgomery, of Austin, Tex., is thus reported:

We planted the Sudan grass broadcast, about like oats, on a rich but rather droughty piece of land (black waxy) which, however, had been well prepared and was in good condition. Since planting, May 7, we have had one good rain, June 17. The grass had withstood the drought well and made a very rapid growth, attaining an average height of 5 feet. Although very similar in appearance to Johnson grass, I consider it far superior as a forage crop, as it is much more bunchy, putting out more stems and a great many more leaves than Johnson grass. The stems are very sweet, containing a great deal of sugar, and are eaten greedily by both cows and horses, none of it being wasted, as is so often the case with the coarser grasses. I should judge that it would make double the amount of hay made by Johnson grass under the same conditions. The root system is very much like that of oats or crab-grass and there is no danger of the land becoming infested, as it is easy to kill out. I plowed across one end of my patch of Sudan grass with a sweep, turning the bunches up, and there has been no sign of its reappearance.

I cut the hay after saving all the seed, and the grass is again sprouting, although there has been no rain.

Next year I expect to plant all the seed I have, as Sudan grass has proved itself far superior in quality and quantity to any of the grasses in this locality. I shall also try it on land infested by Johnson grass, as I have an idea that if planted thick enough it will choke out the Johnson grass in the course of two or three years.

KANSAS.

Mr. J. M. Gilman, of Leavenworth, Kans., made a small trial in 1912 with the following results:

I made two plantings of Sudan grass, one early and one later. The early planting, April 25, in 12-inch rows, was of much less growth and fell down and shattered seed badly. The later planting, May 20, was one-fifteenth of an acre in rows 42 inches wide and was cut twice, the first cutting yielding 346 pounds and the second 267 pounds of cured hay. The first cutting was left a little too long, but was cut about September 10; the next cutting was made October 14.

ALABAMA.

Mr. Charles Anderson, of Axis, Ala., grew Sudan grass in 1912 and gave his experience as follows:

I planted the Sudan grass seed May 2 and cut it twice. I am unable to give you the amount in pounds, as I had no way of weighing. It grew very rapidly and made a very heavy crop, which I would estimate at $1\frac{1}{2}$ tons to the acre per cutting. The stock ate it greedily, but I did not have enough to demonstrate what it did for them, though they were fond of it. I would consider it a valuable crop to grow.

SOUTH CAROLINA.

Mr. R. Bates, of Jackson, S. C., made the following report:

I cut this grass twice. It went to seed twice, once from the grain and again from the stubble. The seed yield was poor, being but 10 bushels per acre for both harvests. It makes a hay yield fully equal to Johnson grass.

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U. S. DEPARTMENT OF AGRICULTURE.

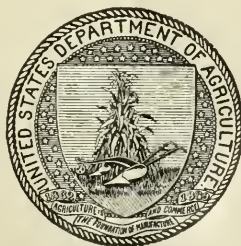
BUREAU OF PLANT INDUSTRY—Circular No. 126.

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

Fungous Diseases Liable to be Disseminated in Shipments of Sugar Cane .	ETHEL C. FIELD
The Work of the Yuma Experiment Farm in 1912	W. A. PETERSON
Directions for Collecting Plants	P. L. RICKER

Issued May 10, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, WILLIAM A. TAYLOR.

Assistant Chief of Bureau, L. C. CORBETT.

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[Cir. 126]

FUNGOUS DISEASES LIABLE TO BE DISSEMINATED IN SHIPMENTS OF SUGAR CANE.¹

By ETHEL C. FIELD, *Scientific Assistant, Office of Cotton and Truck Disease and
Sugar-Plant Investigations.*

INTRODUCTION.

Sugar cane in the United States has been relatively free from fungous diseases so far, but as the industry grows it is to be expected that foreign diseases will creep in along with imported sugar cane for propagation, as has already happened in a few instances. Every effort should be made to eliminate these diseases and to prevent the further introduction of new ones. Since inspection is not adequate, the most feasible method of dealing with sugar-cane imports is to grow them under quarantine. Mr. E. J. Butler, imperial mycologist of India, who is familiar with cane diseases in Bengal, makes practically the same suggestion respecting imports into that country. He states in his discussion of the red-rot stem disease that "experience has shown—explain it how we may—that new importations are particularly liable to fall a prey to disease. Where a foreign variety is introduced it will probably be better to grow it for some years in seed beds with careful cultivation before planting out on a large scale."²

A brief description of some of the most important diseases is here given, being mostly compiled from foreign publications. The various leaf diseases have not been included, although the annual loss caused by them is not inconsiderable.

RED-ROT OF THE STEM.

Red-rot of the stem (*Colletotrichum falcatum* Went) was first detected by Dr. F. A. F. C. Went in 1892 at the Tjomal factory in Java. He described the disease later under the name of red-smut, which has since been supplanted by the above name on account of the presence of a true smut on sugar cane. The disease has become widely distributed over cane-growing regions, having been reported from Queensland, Bengal, Madras, Madagascar, Hawaii, and the West

¹ Issued May 10, 1913.

² Butler, E. J. Fungous diseases of sugar cane in Bengal. Memoirs, Department of Agriculture, India, Botanical Series, v. 1, no. 3, p. 22, 1906.

Indies. More recently (1908) it was discovered by Dr. C. W. Edgerton¹ at Audubon Park, New Orleans. It has also been reported from Florida and Georgia.

It is difficult to estimate the amount of damage caused by red-rot, since this does not consist of a loss in stand alone; but, as shown in experiments conducted by Mr. Butler² in Bengal, the most serious loss consists of a decrease in sucrose content with an increase of glucose brought about through the action of the parasite.

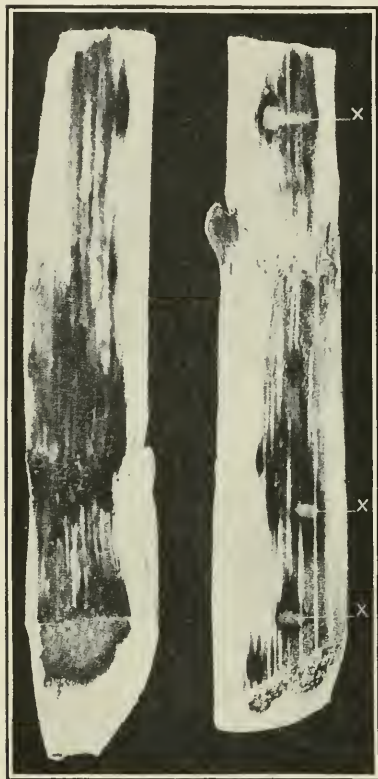


FIG. 1.—Red-rot of sugar cane, showing white spots (x) in center of red blotches. (After Lewton-Brain.)

The presence of the disease in the field usually does not become evident until the cane is approaching maturity. A slight drooping of the upper leaves then becomes noticeable. The leaves wither at the tip, advancing along the margin of the leaf, leaving a green center. Finally the whole crown droops, although the stalk remains apparently healthy. According to Butler the diseased plants have the same appearance as those affected by drought, except that green and withered stalks may be seen arising from the same stool. In a bad attack these withered stalks become light in weight, fall over, and contain practically no juice.

If a stalk is split open at the base during the early stages of the disease, the fibrovascular bundles may be seen as reddened streaks, which gradually increase in diameter, spreading outward into the neighboring tissue. Later, white blotches consisting of dead cells filled with air may be found in this reddened area. (See fig. 1.) The disease advances upward toward the tip, the tissue finally becoming dark to blackish in color. If the stool is examined it will be found that the discoloration of the stalk extends downward into the cutting and may be traced from here into other stalks which outwardly seem perfectly normal. The fungous spores are usually

¹ Edgerton, C. W. The red-rot of sugar cane, Louisiana Agricultural Experiment Station, Bulletin 133, 22 p., 4 pl., 1911.

² Butler, E. J. Fungous diseases of sugar cane in Bengal. Memoirs, Department of Agriculture, India, Botanical Series, v. 1, no. 3, 53 p., 11 pl., 1906.

formed on the dry sugar cane at the nodes or in sunken areas on the internodes.

There has been considerable doubt among investigators as to the manner in which the disease is distributed. Some attribute its spread entirely to the agency of cane borers. Dr. Edgerton states that in Louisiana the infection takes place chiefly through the agency of the moth borer (*Diatraea saccharalis*). In an examination of 55 borer cases, he found that 25 were infected with red-rot, 25 not diseased, and 5 doubtful.

Mr. Butler concludes from his observations that the disease is carried in the sets themselves. He found that the yellow Bourbon cane which came from infected districts gave diseased shoots, while the same variety obtained from disease-free regions and grown adjacent to the former plants produced healthy shoots. It would seem from this experiment that the use of diseased stalks for cuttings is the chief source of infection, although cane borers undoubtedly spread the disease to some extent in those fields already infested with spores from the previous season's growth.

While the disease may be detected in many cases by inspection, an absolute guaranty of disease-free cane could not be given. Mr. Butler also says that—

Unfortunately, even with the greatest care it is not possible to eliminate diseased sets entirely, for I have obtained cultures of the fungus from sets passed by a particularly careful man, and the reddening does not always show at the cut ends.

And in speaking of the red discoloration of the tissue, which is considered the chief diagnostic character, he states that—

There is no peculiarity in this discoloration that I have been able to find which serves to distinguish it in all cases from the reddening due to other causes.

Control.—Selection of resistant varieties and selection of "seed" are recommended for controlling the red-rot.

ILIAU.

Iliau (*Gnomonia iliau* Lyon) is a disease apparently peculiar to Hawaii, where it is said to have been known since the beginning of the sugar industry. Although the disease has been recognized for many years, it was not until 1912 that the entire life history of the causal organism was worked out and published.¹

Dr. Lyon considers that far greater losses to the sugar planters in Hawaii have occurred from this disease than that caused by all other fungoid diseases combined. The following instances of loss are quoted from his bulletin:

The manager of one plantation estimated that fully one-half of the shoots in a 200-acre field of 4-months-old plant cane had been killed out by iliau. His estimate was

¹ Lyon, H. L. Iliau, an endemic cane disease. Report of Work of the Experiment Station, Hawaiian Sugar Planters' Association. Pathological and Physiological Series, Bulletin 11, 32 p., 10 fig., 1 pl., 1912.

made at a time when the disease was at its height in the field. At a later period, during warm weather, this cane recovered rapidly, the stand being greatly augmented by new shoots. When the field was finally harvested the yield in sugar was about 20 per cent less than the average amount which this field could be expected to produce. The loss in this case amounted to a little over a ton of sugar on each acre. As no other

disturbing factors appeared during the growth of this crop, the loss can very reasonably be ascribed entirely to iliau.

We have seen several cases where iliau has killed all of the stools over small areas of plant cane and one case where it effectually destroyed the cane over an area of 15 acres. We have seen many instances where the disease has killed from one-fourth to one-half of the primary shoots in large fields, our estimates for several cases being based on careful counts made in various parts of the affected areas.

Iliau is a Hawaiian expression meaning "tight skin" or "hidebound," having reference to the manner in which the leaf sheaths are firmly held together around the stem by the fungous mycelium. Any attempt to remove the leaves is met with considerable resistance. The fungus gains an entrance into the tissue of the cane at the leaf bases usually below the surface of the ground and from here makes its way into the leaf sheaths, working upward and then inward. The leaves whose sheaths are diseased soon die but do not fall off, as they are tightly cemented to the sheaths within. (See fig. 2.) On young cane this tight case prevents the shoot from elongating and thus eventually kills the terminal growing point. If the stem or shoot outgrows the mycelium, i. e., before the fungus has penetrated the inner sheaths, the disease does little harm. The fungus can make material progress only in young and tender tissues, and even if it has entered the stem its growth is checked by the normal hardening of the tissues. The dead leaf sheaths are



FIG. 2.—Iliau disease of sugar cane after an attempt to remove the leaves. (After Cobb.)

pinkish brown in color and the rind, if any growth has been made, is deep bluish gray.

The imperfect form of this fungus (*Melanconium*) is the one most commonly met with on the diseased shoots. It belongs to the same

genus as the fungus causing rind disease of cane. There should be no confusion in distinguishing the two diseases in the field, the one being a vigorous parasite attacking only young shoots, while the other is a saprophyte found on cane killed from some other cause. The spores are formed in pustules usually within the tissue of the stem or the inner leaf sheaths and are not released until the stem disintegrates. So long as the shoot remains dry the pustules remain intact, but when moistened the sheaths loosen and the spores are freed.

The disease flourishes only during damp, cool weather and then only on young shoots. Fields in which the cane is more than half grown are not affected, the disease being confined in that case to the young shoots or suckers.

Inspection of seed sugar cane for this disease would be inadequate, since the disease is usually not evident on mature cane. Spores of the fungus might be carried on the surface of the lower portions of the stalks which had outgrown the disease or might find lodgment on healthy cane coming from infected areas and the disease be thus carried.

Control.—Thorough preparation of the soil previous to planting is recommended in controlling the disease, since an exposure of the spores and mycelium to the sun for a few hours effectually destroys them.

GUMMING.

Gumming (*Bacterium vascularum* (Cobb) Greig-Smith), a disease of the fibrovascular bundles of sugar cane, was first described in 1893 by Dr. N. A. Cobb¹ from the Clarence River district of Australia. It is also present in Mauritius, Java, and Brazil. While this trouble has so far been easy to control in infected regions it might become far more serious if introduced into a new habitat.

The disease is characterized² by a dying of the cane tops, a rotting of the tissues at the base of the "arrow," and the production of a yellowish gummy substance in the bundles of the stem. Gumming is propagated through diseased sets. The bacterial organism advances in the bundles of the stem along with the growing plant. In severe cases the plants are dwarfed, attaining in a year's growth only a third or half the size of healthy plants. Occasionally the young plants are killed before they have had time to push through the ground. If a diseased stalk is cut crosswise, a sticky yellowish sub-

¹ Cobb, N. A. Diseases of the sugar-cane. *Agricultural Gazette of New South Wales*, v. 4, pt. 10, p. 777-833, 46 fig., 1893.

² Cobb, N. A. Third report on gumming of the sugar cane. Report of Work of the Experiment Station, Hawaiian Sugar Planters' Association. Division of Pathology and Physiology, Bulletin 3, 46 p., 12 fig., 2 pl., 1905.

stance exudes from the bundles in the form of tiny drops. (See fig. 3.) This is the most characteristic symptom of the disease. Ordinary inspection, however, is not sufficient to detect this disease in cases where the cane is only slightly attacked.

Control.—Selection of cuttings and growing of resistant varieties are recommended.

SMUT.

Smut (*Ustilago sacchari* Rabenhorst) is rather widely distributed in cane-growing countries, but usually does little damage. Mr. Butler describes the disease as follows:

Affected plants are known by the production from the growing apex of a long whip like dusty black shoot, often several feet in length and much curved on itself. (See fig. 4.)

This shoot is an entirely abnormal growth, devoid of leaves, slender, and flexible. It must probably be taken to represent an abnormal floral shoot. In its earlier stages it is covered by a silvery white thin sheath which soon, however, ruptures, exposing a dense black dust consisting of the spores of the fungus.

From the upper portion of the affected cane no secondary shoots arise, but from its lower part they are fairly abundant, being all in their turn attacked and prolonged into spore-containing organs. In this way it becomes evident that the whole plant is affected.

The tissues of the cane below the abnormal shoot contain the filaments of the smut fungus. These are found between the cells, not in them, as is the case with *Colletotrichum falcatum*. Diseased canes are poor in sugar and worthless.¹

The disease may be transmitted through spores coming in contact with healthy plants or through diseased sets. The latter means is probably the most frequent.

Control.—Care should be exercised to prevent the spread of spores through tools, clothing, packing, manure, etc., and only cane from healthy plants should be used for the sets.

SEREH.

The cause of seresh is unknown, although it has been recognized as far back as 1882 in Java, where it has done much damage.² Dr.

Lyon reports it to be of rare occurrence in the Hawaiian Islands, having been first recorded in 1908.



FIG. 3.—Gumming disease of sugarcane, showing gummy exudations on cut surface of cane. (After Cobb.)

¹ Butler, E. J. Op. cit.

² Deerr, Noël. Cane Sugar. Altrincham (Manchester), p. 145-147, fig. 72, 1911.

Mr. Noël Deerr states that—

In the typical form of "sereh" the stool of cane consists of a number of short stalks with very short joints; the buds, especially those below, sprout, whereby results a bundle of short stems hidden in a mass of leaves. The whole stool bears a resemblance to lemon grass (*Andropogon schoenanthus*), the Javanese term for which is "sereh." In a second type one or two stalks may grow to a fair size with very short joints in the upper part; above all is a fan-shaped leaf crown; many of the eyes, especially those below, sprout and form small branches. * * * A red coloration of the fibrovascular bundles is a characteristic of "sereh." This coloration is most pronounced in the node, but often appears in the internode in the form of a red stripe. This appearance is quite distinct from the red patch with white center characteristic of the red-rot of the stem.

A point of great interest with this disease is the difference of opinion as to its infective nature. The disease certainly spread from district to district in Java, but, conversely, healthy sticks planted in an affected field remained healthy. Whether infectious or

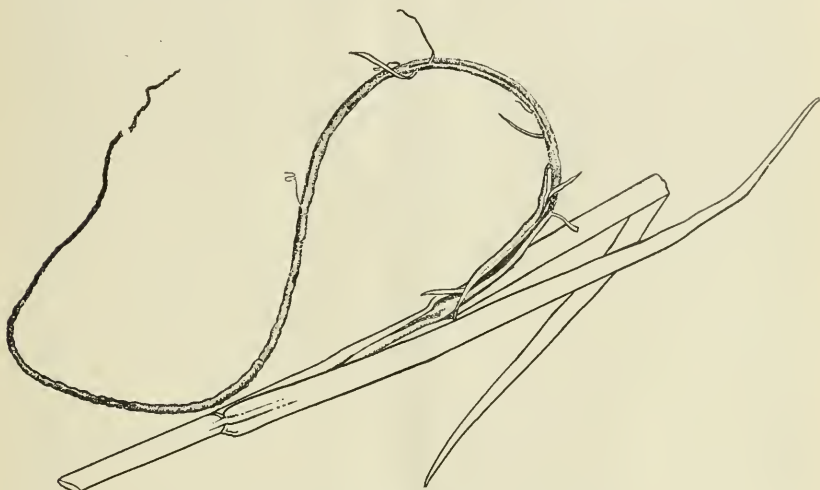


FIG. 4.—Smut disease of sugar cane. (After Butler.)

not, the disease was found to be hereditary; that is to say, canes planted from sound, healthy seed gave healthy canes, but tops derived from sereh-struck canes became equally infected.

THE PINEAPPLE DISEASE.

The pineapple disease (*Thielaviopsis paradoxa* (De Seyn.) V. Höhn) was first studied by Dr. Went in Java in 1893. Since that time it has been found also in Mauritius, British Guiana, the West Indies, Hawaii, and was reported from Louisiana in 1910. Mr. Butler reported that up to 1906 he had found the pineapple disease in Bengal on only three occasions and these were on cane which had been imported from Java and Mauritius for seed. This disease is one which chiefly attacks the planted cuttings, the fungus being a wound parasite. Considerable damage is caused wherever this disease is

prevalent through a failure of the "eyes" to germinate. Dr. Cobb considers the pineapple fungus to cause the decay of more cane cuttings in Hawaii than that produced by any other one cause and has estimated that in diseased fields the loss varies from 1 to 25 per cent of the plantings. Fortunately the disease has not become widely distributed in the United States, having only been reported from a few localities in Louisiana.¹

The fungus effects an entrance into the cane at the cut ends of the "seed" or at any point along the stalks through wounds of the rind made either by mechanical or insect injury. The disease (fig. 5), marked by pink or red streaks, progresses rapidly through the central tissues of the cane, eventually killing the buds and thus preventing germination. Later, this central diseased tissue turns dark and finally sooty black through the production of macroconidia. This blackened central tissue is what is known as the "pipe"² and is one of the chief characteristics of the disease.

It is in the younger stages of the disease that the pineapple odor may be detected, being more noticeable in some varieties of cane than in others. These two characters, viz, the "pipe" and the pineapple odor, are the chief marks by which the disease may be detected. The same fungus causes a disease of pineapples.

Control.—Destruction of diseased cane and the immersion of the cuttings in Bordeaux mixture shortly after the cane is cut are recommended. In the West Indies Howard also recommends that the ends of the cane be dipped in tar as a further preservative.

SCLEROTIUM DISEASE.

The Sclerotium disease (*Sclerotium rolfsii* Sacc.) is one which attacks the leaf sheaths principally, being usually confined to the lower sheaths. It was reported from Louisiana in 1908 and has since been found in Georgia. The amount of damage caused is somewhat questionable, some claiming that it is confined to the sheaths and does very little harm, while others assert that the fungus penetrates into the stalk for some little distance and also into the bud, preventing its germination when used in plantings. This disease is probably the same as that described by Krüger³ under the name of red-rot of the leaf sheath and stem and attributed by him to *Sclerotium* sp. He states that the disease is characterized by a brick-red discoloration

¹ Edgerton, C. W. Some sugar-cane diseases. Louisiana Agricultural Experiment Station, Bulletin 120, 28 p., 12 fig., 1910.

² Cobb, N. A. Fungus maladies of the sugar-cane. Report of Work of the Experiment Station, Hawaiian Sugar Planters' Association. Division of Pathology and Physiology. Bulletin 5, 254 p., 101 fig., 7 pl., 1906.

³ Krüger, Wilhelm. Das Zuckerrohr und Seine Kultur. Magdeburg and Wien, p. 459-464, pl. 14, fig. 2 3, 1899.

of the sheath, which does not have a definite border. Later, the discolored tissue near the center takes on a blackish, sooty tinge.

The Sclerotium disease enters the stem through the bundles at the point of attachment of the leaf and then advances both above and below the node, frequently forming cankers on the stem. (See fig. 6.) Infection rarely, if ever, takes place at the internodes. If

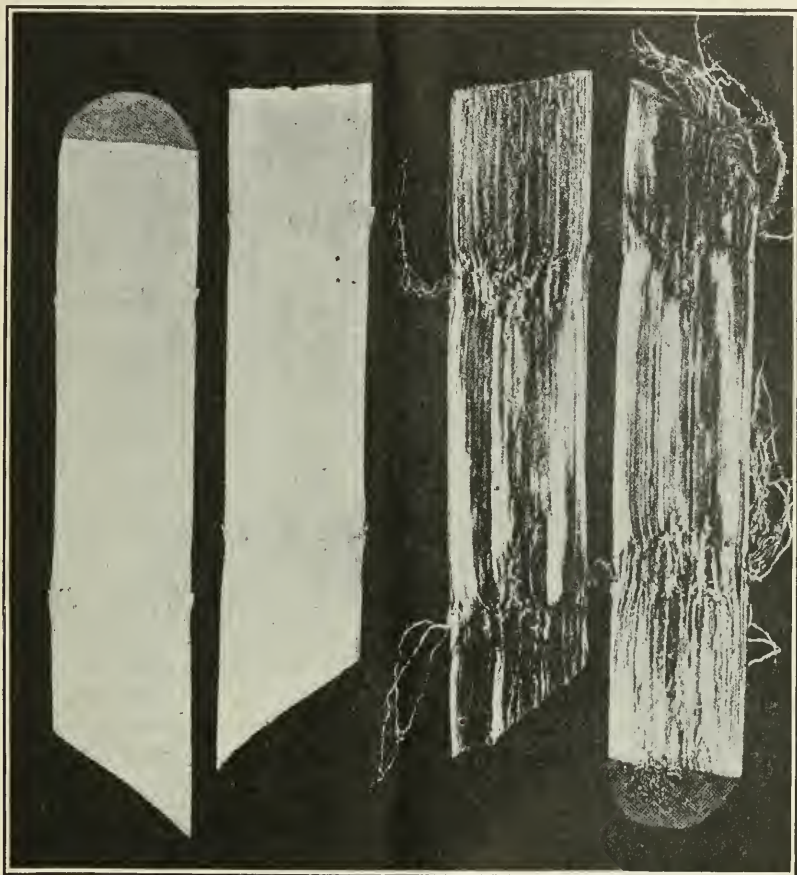


FIG. 5.—Pineapple disease of sugar cane. The cutting at the right was completely ruined in a few days, although its condition when planted was like that of the sample shown at the left. (After Cobb.)

the attacked leaf sheath is pulled off there may be seen a network of fine white shiny threads of the fungus at the base of the sheath. Later, the sclerotia, or resting stage of the fungus, consisting of small round bodies, at first white, then light yellow, and finally brown, are formed. These sclerotia remain in the tissue of the cane or drop off on the ground and are capable of carrying the fungus through conditions unfavorable for its growth, such as dryness. Under favorable

conditions, usually in the spring, these bodies produce the mycelium, which may penetrate those leaf sheaths with which it comes in contact. The disease flourishes during damp weather.

Control.—Removal and burning of the lower leaf sheaths and leaves are recommended. Infected cuttings should not be used for plantings.

Krüger states that if infected cuttings come up at all they seldom produce well-developed plants.

ROOT DISEASE.

Root disease is probably present in all the sugar-cane regions of the world. It is commonly caused by one of the following fungi: *Marasmius plicatus* Wakker, *M. sacchari* Wakker, or *Ithyphallus coralloides* Cobb. Great losses have been sustained from this trouble. Dr. Cobb¹ estimated that in Hawaii failures frequently amounted to 25 per cent and in a few cases as high as 50 or 60 per cent, while a conservative estimate was placed at 10 per cent of the ratoon crop and a somewhat smaller loss on the plant crops. In Louisiana Prof. H. R. Fulton² states:

It is a usual thing to find the purple plant cane affected to the extent of 5 to 8 per cent of the stalks, and purple first-year stubble, 12 to 18 per cent. In the case of D 74, 1 to 3 per cent and 4 to 8 per cent are usual figures for the corresponding crops. Some of the worst fields seen have been in purple cane and have had 90 or 95 per cent of the stalks infected. These figures are not to be taken as representing in any way the loss due to the root disease. Affected canes, although usually small and light, are by no means a total loss; and the figures do not take into account the gaps in

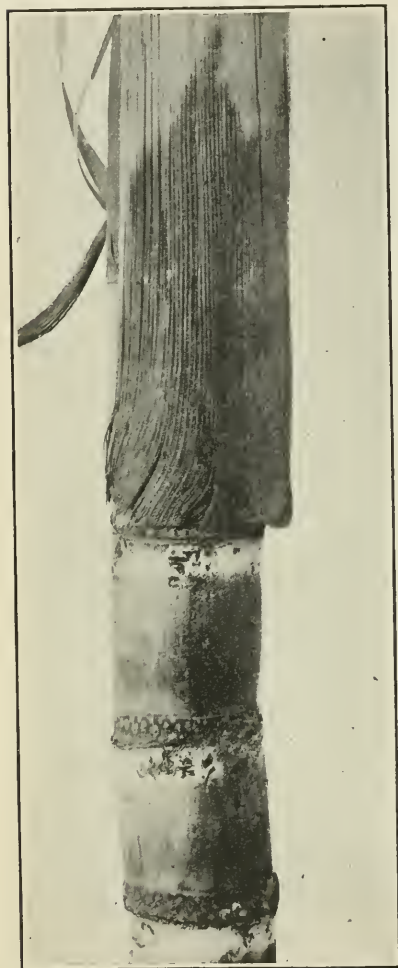


Fig. 6.—Sclerotium disease of sugar cane, showing darkened, sunken areas below the nodes.

stands and the reduction in number of canes per stool that make up the large loss from root disease.

¹ Cobb, N. A. Op. cit.

² Fulton, H. R. Root disease of sugar cane in Louisiana. Louisiana Agricultural Experiment Station, Bulletin 100, 21 p., 8 figs., 1908.

The organisms causing root-rot are wound parasites, usually living a saprophytic life in the soil. When the cane is weakened from any cause, such as drought, poor cultivation, etc., the fungus can make an entrance into the roots. The root first shows a reddening of the surface, followed by a brown discoloration, and finally a slow disintegration. Plants so affected are weak and dwarfed and easily blown over by the wind or uprooted. The lower leaf sheaths are frequently enveloped in a white web of fungous threads which cement them tight to the stalk. The disease is much more prevalent on ratoon crops than on planted cane, as it lives and grows on the stubble year after year. On planted cane the fungus envelops the stalk and soon smothers the buds, thus preventing germination and resulting in a poor stand.

Control.—Dr. Fulton suggests the following preventive measures: (1) Careful cultivation, (2) selection and disinfection of seed cane, (3) planting of resistant varieties, (4) destruction of infected trash, and (5) rotation. So far as known, no other crop is affected by root disease except sweet potatoes.¹ This has been reported from Barbados, St. Lucia, and Antigua, of the West Indies.

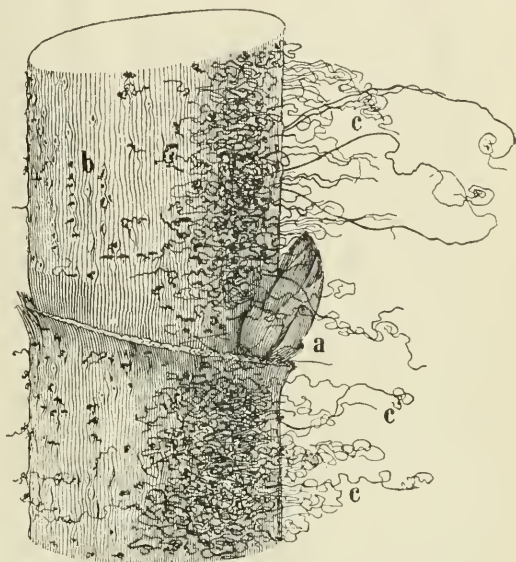


FIG. 7.—Rind disease of sugar cane, showing long, black threads of spores at "c." (After Cobb.)

RIND DISEASE.

Rind disease (*Trichosphaeria sacchari* Masee) was once held to be the cause of a great amount of damage in the West Indies and elsewhere. More recently the rind fungus has been considered by various investigators to be a secondary factor appearing only after the cane has been weakened from some cause or following some parasite such as the red-rot organism. The fungus causes little damage other than hastening the complete destruction of already diseased cane. (See fig. 7.)

¹ South, F. W. Disease of sweet potatoes. West Indian Bulletin, v. 11, No. 2, p. 82, 1911.
[Cir. 126]

THE WORK OF THE YUMA EXPERIMENT FARM IN 1912.¹

By W. A. PETERSON, *Farm Superintendent, Office of Western Irrigation Agriculture.*

INTRODUCTION.

The Yuma Reclamation Project is characterized by climatic conditions peculiarly favorable to the production of a great variety of crops. The rainfall of the region averages only about 3 inches a year and is not a factor in crop production. The climate is warm during most of the year, the temperature for a period of 35 years ranging from a minimum of 16° to a maximum of 120° F. These conditions are specially favorable to such crops as cotton, alfalfa and alfalfa seed, figs, dates, sweet potatoes, and other crops which require a warm climate and which are well suited to intensive culture.

Since the establishment of the Yuma Experiment Farm (fig. 1) on its present site in 1909, experiments have been conducted with a



FIG. 1.—View of buildings on the Yuma Experiment Farm.

view to improving the cultural methods applicable to the above-named crops, to finding superior varieties, and to breeding superior strains of the varieties under test. Much of this work is done in cooperation with other offices of the Bureau of Plant Industry. The offices concerned in the cooperative work in 1912 are the following: The Office of Crop Physiology and Breeding Investigations

¹ Issued May 10, 1913.

The Yuma Experiment Farm is located on the Yuma Reclamation Project, 7 miles north of Yuma, Ariz., and adjacent to Bard, Cal. It consists of 160 acres of land, all of which is irrigable. The land was withdrawn from entry in 1909 by the Department of the Interior to be used as an experiment farm. Operations on the tract were begun in the spring of 1910. A farmhouse and an office building were constructed by the Reclamation Service; a tool house and a machine shed have been built by the United States Department of Agriculture. (See fig. 1.) The farm is under the direct supervision of a superintendent detailed from the Office of Western Irrigation Agriculture, Bureau of Plant Industry, and that office furnishes the funds necessary to maintain the farm. On January 1, 1913, Mr. R. E. Blair succeeded Mr. Peterson as farm superintendent.

cooperates in the work with figs and dates; the Office of Foreign Seed and Plant Introduction in the work with bamboo, carobs, etc.; the Office of Acclimatization and Adaptation of Crop Plants and Cotton-Breeding Investigations in cotton acclimatization; the Office of Alkali and Drought Resistant Plant Investigations in breeding Egyptian cotton; the Office of Corn Investigations in testing corn varieties; the Office of Cooperative Cotton Handling and Marketing and Paper-Plant Investigations in the work with ramie; the Office of Fiber Investigations in the experiments with hemp; and the Biophysical Laboratory in the climatological observations.

CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

In Table I the climatological observations made at the experiment farm in 1912 are briefly summarized, together with a statement of the average weather conditions during the three years 1910 to 1912, inclusive.

TABLE I.—*Summary of the climatological observations at the Yuma Experiment Farm, 1910 to 1912, inclusive.*

PRECIPITATION (INCHES).													
Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for 3 years, 1910 to 1912.....	0.22	0.37	0.48	0.18	0.25	0.17	0.37	0.05	0.19	0.35	0.26	0.003	2.886
For the year 1912.....	0	0	.89	.26	.75	.51	.29	.13	0	.33	0	.01	3.08
EVAPORATION (INCHES).													
Average for 3 years, 1910 to 1912.....	3.42	4.48	6.92	6.58	10.8	11.25	10.29	10.31	8.27	6.47	4.46	3.41	86.66
For the year 1912.....	3.96	5.30	7.71	6.40	9.0	10.14	9.44	9.00	7.63	5.61	4.19	2.86	81.24
DAILY WIND VELOCITY (MILES PER HOUR).													
1910, highest.....	.....	.....	.....	.....	9.0	8.8	7.4	7.2	4.6	9.2	6.3	6.4	.....
1911, highest.....	7.4	8.5	5.4	9.2	8.1	6.3	6.0	3.2	4.1	6.7	10.1	9.9	.....
1912, highest.....	5.4	7.4	9.3	8.4	6.9	4.4	5.1	5.9	4.7	7.9	11.4	10.8	.....
1910, lowest.....	.....	.....	.....	.....	2.3	1.1	1.5	2.0	1.2	.8	1.7	1.8	.....
1911, lowest.....	.8	.8	1.3	1.5	1.9	1.4	1.3	0	1.1	.8	1.0	1.3	.....
1912, lowest.....	1.5	1.1	1.4	1.7	1.5	1.0	1.5	1.2	.3	1.2	1.3	.8	.....
1910, average.....	.....	.....	.....	.....	4.1	3.8	3.6	3.4	2.4	3.7	3.3	3.5	.....
1911, average.....	3.0	3.5	2.7	3.8	3.3	2.9	2.5	2.0	1.7	2.5	3.7	3.5	.....
1912, average.....	3.2	4.0	3.9	3.8	3.3	2.6	2.3	2.3	2.1	3.0	2.9	4.0	.....
TEMPERATURE (°F.).													
Absolute maximum:													
3 years, 1910 to 1912.....	84	88	94	106.5	120	117	116	113	116	107	94	81	120
For 1912.....	84	88	87	91	103	114	109	111	107	95	88	75	114
Absolute minimum:													
3 years, 1910 to 1912.....	18	27	32	35	42	47	54	61	51	36	28	16	16
For 1912.....	18	27	32	36	42	54	58	61	51	36	34	23	18
Mean:													
3 years, 1910 to 1912.....	54.1	54.6	61.5	69.0	73.6	81.6	88.0	88.3	82.3	70.2	60.1	51.1	69.5
For 1912.....	53.5	56.4	59.2	65.1	72.3	82.7	85.8	85.8	78.5	68.5	59.7	51.0	68.0

TABLE I.—*Summary of the climatological observations at the Yuma Experiment Farm, 1910 to 1912, inclusive—Continued.*

KILLING FROSTS.

Years.	Last in spring.		First in autumn.		Frost-free period.
	Date.	Minimum temperature.	Date.	Minimum temperature.	
		° F.		° F.	Days.
1910.....			Nov. 27	32	.....
1911.....	Feb. 24	32	Nov. 14	32	262
1912.....	Mar. 31	32	Dec. 4	31	247

CROP CONDITIONS.

The crop conditions on the project were generally favorable during the year 1912. In the early part of June the flood waters of the Colorado River caused some damage from seepage on the lands near the river, and some parts of the project were damaged by the rise of underground water from the river and from the excessively irrigated higher lands. The areas seriously affected by these difficulties comprise, however, only a small part of the project and the conditions on these areas are being improved by the construction of a large drainage ditch.

The total irrigable area of the farms on the project in 1912 was 27,592 acres, included in 470 farm units. Of this area, 13,767 acres were actually irrigated, and crops were harvested from 11,060 acres. The acreage, yields, and farm values of the crops on the project in 1912 are stated in Table II. The figures were obtained from the United States Reclamation Service.

TABLE II.—*Acreage, yields, and farm values of crops grown on the Yuma Reclamation Project in 1912.*

Crop.	Area.	Unit of yield.	Yield.			Farm value.			
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.	
				Average.	Maximum.			Average.	Maximum.
	<i>Acres.</i>								
Alfalfa hay.....	7,269	Ton.....	27,078	3.73	10.00	\$10.00	\$270,780.00	\$37.30	\$100.00
Alfalfa seed.....	2,824	Pound.....	814,186	288.00	900.00	.10	81,418.60	28.80	90.00
Alfalfa straw ¹	2,824	Ton.....	3,000	1.06	2.00	5.00	15,000.00	5.30	10.00
Barley hay.....	208	do.....	416	2.00	2.50	9.00	3,744.00	18.00	22.50
Grain sorghum.....	986	Bushel.....	31,372	31.80	100.00	.75	23,529.00	23.85	75.00
Wheat and barley ²	1,567	do.....	55,357	35.30	60.00	.75	41,517.75	26.47	45.00
Corn.....	294	do.....	6,602	22.50	40.00	.75	4,951.50	16.87	30.00
Cane.....	292	Ton.....	1,252	4.30	8.00	5.00	6,260.00	21.50	40.00
Cotton.....	25	Pound.....	5,800	232.00	500.00	.20	1,160.00	46.40	100.00
Truck crops.....	431						19,902.00	46.30	
Pasture.....	575						28,750.00	50.00	
Less duplications.....	5,735								
Total.....	11,060						497,012.85		
Average value.....								44.94	

¹ "Alfalfa straw" is the residue left after the alfalfa seed is removed from the plants. Its farm value on the Yuma Project in 1912 was estimated at one-half that of alfalfa hay.

² The yield and farm values of these grains were not segregated in the reports made by the Reclamation Service.

CROP EXPERIMENTS.

The experiments conducted at the Yuma Experiment Farm in 1912 included chiefly alfalfa, cotton, corn, dates, figs, and truck crops. The arrangement of the fields and the location of the crop experiments in 1912 are shown in figure 2. Cultural experiments were conducted with these and with some miscellaneous crops, and

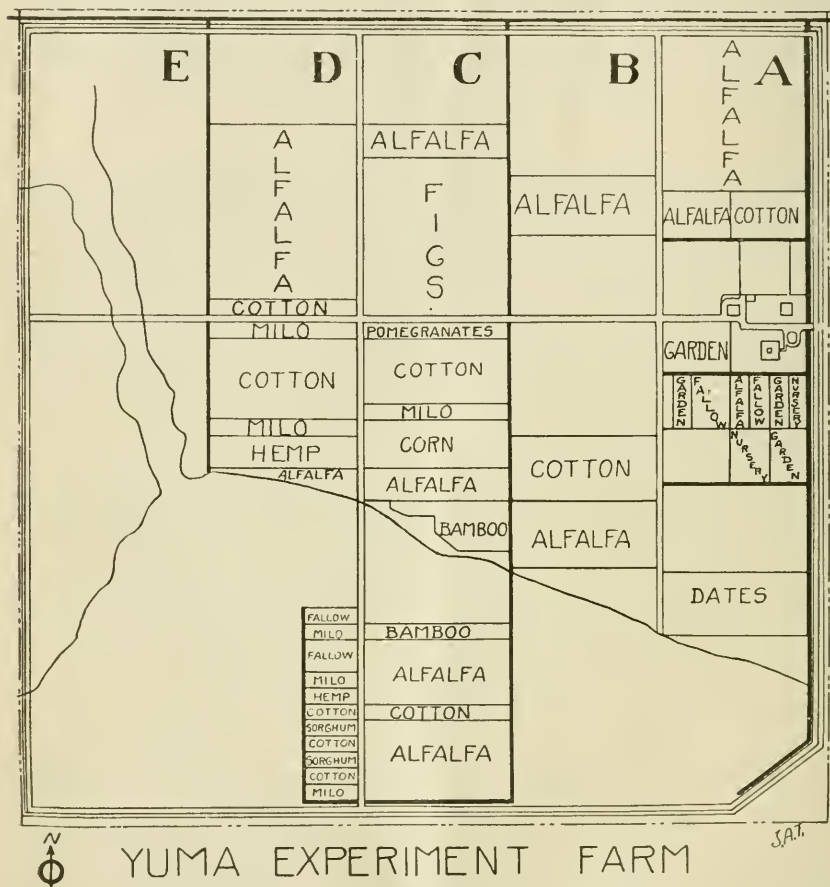


FIG. 2.—Diagram of the Yuma Experiment Farm, showing the arrangement of the fields and the location of the experiments in 1912.

some variety testing and breeding work was done with corn, cotton, dates, and figs. Most of the experimental work was a continuation of work started in previous years, and the following brief discussions of the different crops are based on the results obtained at the experiment farm, not only in 1912 but to some extent in previous years as well.

ALFALFA.

Alfalfa is the most important crop grown on the project. Failure to secure a perfect stand by the usual method of broadcast seeding often enables Bermuda grass to secure a foothold and ultimately crowd out the alfalfa. The experiments conducted at the experiment farm in starting alfalfa have indicated that the methods described below can be expected to result successfully. It has been found that fields planted with a grass-seed drill or a grain drill with a grass-seed attachment usually produce a uniform stand. It is important that the land be first properly leveled and the grade on the fields made not to exceed 1 inch to 200 feet. After plowing, a thorough irrigation is given. The soil is cultivated as soon as possible after irrigation, in order to form a loose soil mulch. Spike-tooth and disk harrows are excellent implements for this purpose. Soon after the preparation of the seed bed the seed is planted sufficiently deep with a drill, so that all seed are deposited in the moist soil directly underneath the mulch. When alfalfa is planted with a drill, 8 to 10 pounds of first-grade seed are ample, while 12 to 20 pounds per acre are necessary when the seed is broadcasted. The most favorable planting season is between September 15 and October 15. When planted at this time, alfalfa becomes well rooted before cold weather, and it is not troubled so much with weeds the following spring, as is the case with spring-seeded alfalfa. Where the soil is very sandy it is necessary to irrigate after planting in order to secure proper germination.

The heaviest yields of alfalfa seed are frequently obtained from fields badly infested with Bermuda grass. This appears to be due to the fact that the plants produce seed better when they are far enough apart to be fully exposed to light. From these observations, as well as from results obtained from planting alfalfa in rows 24 to 30 inches apart where the plants have seeded abundantly, it has seemed desirable to try various methods of row planting for the purpose of seed production. Field plantings in rows varying from 18 to 40 inches apart have been made in order to determine the value of this method.

The sandier lands on the project are relatively unproductive at first. The first aim of the farmer should be to increase the fertility by the addition of silt and organic matter. Alfalfa is an exceptionally valuable crop for this purpose. It is irrigated by flooding, and consequently the silt in the irrigation water is deposited uniformly over the field. The decayed roots that remain after plowing alfalfa land, as well as the surface accumulation of leaves, materially increase the humus content of the soil. The sandy areas in spotted fields are

readily indicated by the poor growth of alfalfa. Manure or other fertilizer can be applied to these areas until their fertility is equal to that of the remainder of the field.

BERMUDA GRASS.

Bermuda grass, an introduced plant, has proved an exceptionally troublesome weed. In the Southern States, where it does not produce seed, it is considered a valuable forage grass, but in the vicinity of Yuma it produces seed abundantly. It generally covers the ditch banks, and as a consequence the seeds fall into the irrigation water, which acts as an effective distributing agent. Bermuda grass makes an excellent pasture, but is far inferior to alfalfa for this purpose.

On account of its tenacious character, the grass is difficult to eradicate when it once acquires a foothold in a field. The best method of killing it so far found has been to give a thorough shallow plowing during the summer months, followed by an occasional disking in order to cut up and dry out the furrow slice. This method has been used successfully on the experiment farm. A strong moldboard plow having a cutting edge on the land side is a useful implement for turning over Bermuda-grass sod. If the work is well done, a clean field can be had by fall. It is essential that all irrigation water be kept off the land while this treatment is being applied. If the eradication is not complete, the land can be irrigated late in the fall and a crop of small grain grown, since Bermuda grass does not grow during the winter months. If the eradication has not been complete, the process should be repeated the following summer. The cultivation given to a growing crop of cotton has also been found very effective in Bermuda-grass eradication.

Bermuda grass will grow where the underground water during the flood stage of the Colorado River comes practically to the surface, a condition disastrous to most other crops. It also withstands a rather high alkali content in the soil, and on account of the rapidity with which it spreads when it once secures a scattered foothold it should prove useful in reclaiming alkali areas. On such areas, where alfalfa does not do well, Bermuda grass has a distinct value as a pasture crop, since the forage is highly nutritious and the plants very resistant to the effects of close grazing.

COTTON.

For several years much emphasis has been placed on cotton work in an effort to develop varieties adapted to the climatic conditions of the arid Southwest. The high price which Egyptian cotton commands and the similarity of the conditions in the irrigated sections

of the Southwest to those of the Nile Valley led the Department to believe that Egyptian cotton could be successfully grown in the southwestern United States. Several years of breeding and selection carried on at the experiment farm by the Office of Alkali and Drought Resistant Plant Investigations have resulted in the production of improved varieties of Egyptian cotton. Seeds of one variety, known as the Yuma cotton, have been distributed to farmers in southern Arizona and California. An area of 550 acres was devoted to the production of the improved varieties of Egyptian cotton in the Imperial, Yuma, and Salt River Valleys during 1912.

In addition to the breeding and extension work with Egyptian cotton, extensive experiments along cultural lines have been carried on at the Yuma farm by the Office of Acclimatization and Adaptation of Crop Plants and Cotton-Breeding Investigations. It has been demonstrated that cotton can be reproduced from mature wood cuttings and that cotton plants can be volunteered by protecting the bases of the stems with soil during the winter.

A large number of hybrids between Egyptian and Upland cottons have been made and grown and different methods of making such hybrids have been studied. Many of these hybrids produce fiber of a very superior quality. A number of varieties of Upland cotton have been tested.

During the season of 1912 two stands of roller gins were installed at the experiment farm. These were placed at the disposal of the local farmers in ginning the 1912 crop.

CORN.

Although corn has not yet proved a profitable crop on the irrigated lands of the Southwest, it has seemed advisable to try a number of varieties not commonly grown in the region. The yield is low and often the crop is a complete failure, due to high temperatures or dry winds at blossoming time. The corn worm is also quite injurious. A large number of varieties have been tested in cooperation with the Office of Corn Investigations, but nearly all have been discarded. In 1912, 22 varieties and selections were tested, but the results were not encouraging. Selection 157, a strain of Laguna corn, appears to be better adapted to the climatic conditions than any other variety grown at present. It has an exceptionally tough husk, which greatly reduces the worm injury. Corn yields have varied from 25 to 48 bushels per acre.

DATES.

The Yuma Project is included in the limited area in the southwestern United States where dates can be successfully grown. Large quantities of the date seed have been distributed to settlers on the

project and considerable assistance has been given in encouraging the industry. Three thousand seedlings of desirable varieties have been planted on the farm, from which some excellent new varieties may be expected. The seedling dates include a row that was planted around the farm for ornamental purposes. Offshoots from 15 varieties of imported palms have been planted, and additional varieties will be planted as fast as they become available from other stations. Some difficulty has been experienced in getting transplanted offshoots to grow. The difficulty has been largely overcome by planting the offshoots (fig. 3) in soil having good drainage and then irrigating every other day during the summer months. Date offshoots seem to



FIG. 3.—View showing method of rooting date-palm offshoots in nursery rows on the Yuma Experiment Farm.

require that the immediately surrounding soil shall constantly be in a nearly saturated condition. Under this treatment the percentage of offshoots that do not root has been greatly decreased.

FIGS.

The soil and climatic conditions on the Yuma Project are well adapted to fig culture. Figs of good quality can be placed on the market early in the season. The Smyrna is the best fig that is marketed at the present time. In contrast to the common varieties of figs, which are self-pollinated, the Smyrna fig is cross-pollinated through the agency of a small insect. The requirements necessary to carry this insect through the winter and to insure its presence in

sufficient numbers at the right time in the spring are a serious handicap to the rapid extension of the Smyrna fig industry. It is highly desirable that a fig be originated that will have the excellent qualities of the Smyrna, but which, like the common varieties of figs, will set fruit without insect pollination. More than a thousand seedlings, crosses between the Smyrna and common varieties of figs, have been planted in orchard form (fig. 4) with the hope of securing some new varieties having the above-named desirable characteristics. These seedlings will begin to bear during the season of 1913.

The minimum of 16° F. above zero during the winter of 1911-12 killed nearly all the seedling figs to the ground. Since equally low temperatures may occur at intervals of 10 or 15 years, it is desirable



FIG. 4.—View in the fig orchard on the Yuma Experiment Farm. More than a thousand seedlings, crosses between the Smyrna and common fig varieties, are being tested.

that the new wood on fig trees shall be well ripened before cold weather sets in. This was accomplished at the experiment farm during the season of 1912 by withholding irrigation water from the fig orchard from about the first of August and thus preventing late growth.

VEGETABLES.

A garden for supplying the farm cooperative mess with fresh vegetables has been grown each year. Most of the varieties of vegetables that are recommended by reliable seed houses for planting in the Southwest have been successfully grown when planted during the proper season. There is no good reason why a farmer on the Yuma Project should not have fresh vegetables from his own garden the entire year. Varieties of tomatoes, such as the Dwarf Champion, that have the fruit shaded by dense foliage, are the most satisfactory.

Irish potatoes have not been extensively grown, partly on account of the frequent failures due to improper cultural methods. On the experiment farm this crop has been very successful when properly handled. It has been found that medium sandy soil is best, particularly if it is old alfalfa sod. The land is thoroughly irrigated early in January and plowed as soon after irrigation as possible. The potatoes are planted between January 15 and February 1 in rows $2\frac{1}{2}$ or 3 feet apart, with the tubers 12 to 16 inches apart in the row. It has been found desirable to harrow the soil frequently and to withhold irrigation water until the plants are about to bloom. One light furrow irrigation at the time of blooming, followed by cultivation, is usually sufficient to mature the crop. If irrigation water is kept off the field after the crop reaches maturity the tubers can be harvested as wanted for a period of six weeks.

EUCALYPTUS.

The protecting levees on either side of the Colorado River are 4,000 feet apart. About 1,000 feet of this space is occupied by the river channel. The remainder of the area between the levees is subject to periodic overflows. It is desirable that as much of this land as is not occupied by the river channel shall be covered with timber. It is now covered with cottonwood and willow, neither of which is particularly valuable. It has seemed probable that some of the species of eucalyptus might prove well suited to the situation and serve somewhat to hold the river to its channel and at the same time furnish useful timber.

In 1910, 100 plants of eucalyptus, including the red, gray, and desert gums, were planted on this overflow land. All three of the species have done well, notwithstanding a 3-foot overflow and extremes in temperature varying from 16° to 120° F. The red and gray gums have attained a height of 24 feet and the desert gum a height of 20 feet. These trees have had to compete with the rank growth of native vegetation, consisting of cottonwood, willow, and arrow weed.

There are many waste areas on the project that could be profitably planted to eucalyptus. On account of their deep-rooting habit, these trees obtain their moisture from the underground water and are not dependent on irrigation. Every farmer would find it advantageous to plant an acre or two if for no other purpose than to supply fence posts and fuel. The eucalyptus trees are also desirable for ornamental purposes. A row of the desert gum has been planted around the experiment farm.

MISCELLANEOUS CROPS.

In 1912 half an acre was planted to hemp in order to determine the possibilities for hempseed production on the irrigated lands of the Southwest. The soil was lacking in uniformity. On the spots of medium and heavy soils the hemp attained a height of 10 to 20 feet and seeded abundantly. The seed was harvested, but at the time of writing it had not been sufficiently cleaned to give yield-test weights.

On account of the rapidity of growth of bamboo and the innumerable uses to which it can be put, several hundred plants of two large commercial species from the Orient were planted in nursery rows in 1911. These species have not proved hardy enough to withstand the low temperatures which occasionally occur. However, it is possible that after the plants become well established they will be sufficiently self-protecting to pass through most winters without injury. The bamboo work was extended in 1912 by a half-acre planting on low land in order to determine the adaptability of bamboo to land having a high underground water table.

The carob (*Ceratonia siliqua*), a promising introduction from Spain, is being tested. The plants were frozen to the ground in the winter of 1911-12, but they put out branches from below the ground line and made a good growth during the past summer.

PUBLICATIONS.

The following publications, based wholly or in part on experiments and observations at the Yuma Experiment Farm, have been issued by the United States Department of Agriculture:

- McLachlan, Argyle. The branching habits of Egyptian cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 249, 28 p., 1912.
- Cook, O. F. Results of cotton experiments in 1911. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 96, 21 p., 1912.
- Kearney, T. H. Fiber from different pickings of Egyptian cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 110, p. 37-39, 1913.
- Kearney, T. H. Egyptian cotton as affected by soil variations. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 112, p. 17-24, 1913.
- Scofield, C. S. Suggestions on growing Egyptian cotton in the Southwest. U. S. Department of Agriculture, Bureau of Plant Industry, Western Agricultural Extension Circular, 10 p., 1912.

As rapidly as definite results are obtained at the experiment farm, reports will be published and distributed among the farmers on the project.

DIRECTIONS FOR COLLECTING PLANTS.¹

By P. L. RICKER, *Assistant Botanist, Taxonomic and Range Investigations.*

INTRODUCTION.

Several thousand specimens of plants are sent annually by farmers, florists, nurserymen, and amateur botanists to the United States Department of Agriculture for identification. In many cases the specimens consist of small fragments of the plants, which are not adequate for satisfactory identification and are often without data. Many of these specimens if properly prepared or packed would be valuable additions to the Department collections, but as usually received they are worthless and difficult to identify, requiring an expenditure of time entirely out of proportion to the value of the specimen or the usefulness of the information to the sender. It is with a view to the improvement of such specimens that this paper was prepared.

Most of the specimens are received from persons without a knowledge of the methods of collecting, preparing, and packing for shipment, and it is chiefly to these that the directions are addressed. Abbreviated directions are given on page 35 for those who have not the time or customary outfit for the careful preparation of specimens, but more complete directions will be given first, in the hope that all correspondents will assist in building up a valuable economic collection and materially reduce the amount of time and labor required to make identifications.

THE EQUIPMENT.

The digger.—A stout knife or garden trowel may be used for digging the plant. The most serviceable all-around tool for collecting is, however, a United States Army intrenching tool (fig. 1),² which is like a broad knife, the blade being 8½ inches long, 2 inches wide, and pointed at the end. It is provided with a heavy sole-leather case in which it is held by a spring and is easily attached to a belt. As a possible

¹ Issued May 10, 1913.

² Shown with case and hook for attaching to a belt, in the left foreground of the illustration. These can be obtained from dealers in second-hand Army equipment at a cost of about \$1 each.

addition, the amateur or professional collector will find a light pick¹ very serviceable in a rocky soil. This is about 10 inches long and constructed similar to a mattock, but with one end pointed like a pickax and weighing only about 1½ pounds in addition to the handle. If the pick is made by a blacksmith, he should be instructed to forge the shank into which the handle is wedged not less than 1½ inches in length.

The collecting case.—For those who are collecting plants in the field two methods are available, a third method, that of carrying a press and driers and putting the plants in as collected, being discarded by most of the experienced collectors. First, for short trips on which it

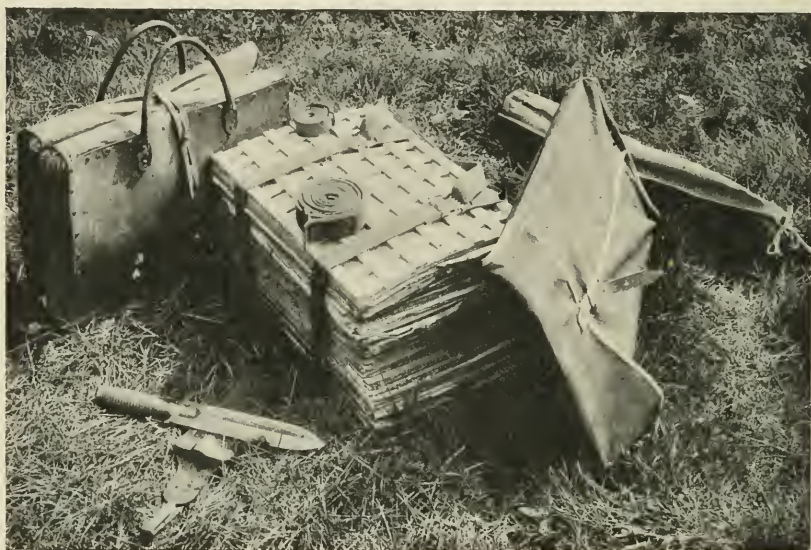


FIG. 1.—A collecting portfolio, bundle of plants in press, plant digger and case, and folding stove used in drying plants, with collapsible smokestack in canvas carrying cases.

is expected to obtain only a few plants a collecting box may be used. This is made of tin and is cylindroid in form, with a cover hinged on the side, and is carried by a strap attached at the ends.

For more extended trips or one on which it is expected to obtain a large number of specimens some form of collecting portfolio is preferable. (Fig. 2.) A very satisfactory one may be constructed from two pieces of heavy binder's board or leather board, measuring 12 by 17 inches. To the long edge (the back) of one, near each end, should be riveted a buckle, and to the corresponding portion of the other board should be riveted two straps about 6 inches long. Thus, the two parts when buckled together have a back adjustable to the number of specimens obtained. To the middle of the upper side of one

¹ These can be obtained from botanical supply companies at a cost of about \$1.75 each.

cover should be riveted another strap, which may be put through a buckle fastened to the corresponding point on the other cover, to keep the covers together. A much more convenient fastening for the strap, however, is a button, similar to that by which the curtains are fastened on a carriage. Short slits to go over the button should be cut in the straps at intervals, doing away with the inconvenience and waste of time involved in fastening and unfastening a buckle. A few inches on either side of the middle strap and its fastening should be fastened the ends of a leather handle. Such a handle should be attached to each cover, so that the two can be used in temporarily holding the covers together. Thus, one avoids the necessity of bothering with the strap every time a plant is put in the portfolio. The portfolio covers should be sufficiently thick to avoid much warping at the corners. The warping can be largely prevented by riveting a thin strip of iron or steel about three-fourths of an inch wide to the inside

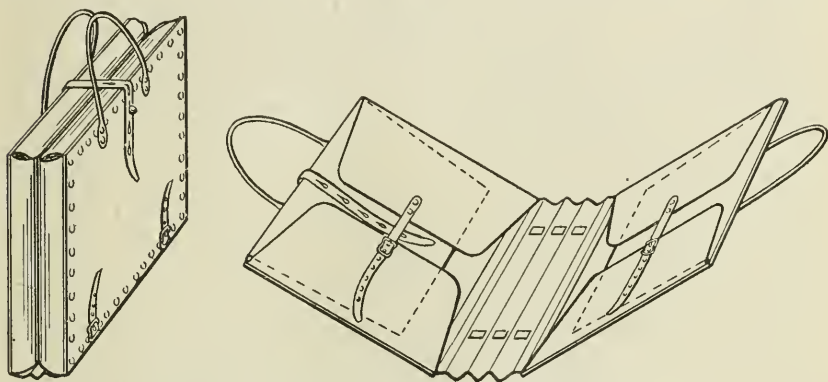


FIG. 2.—A collecting portfolio, showing plan of construction.

of the upper and lower edges of the portfolio covers. If the covers are of heavy binder's board, the total weight of the portfolio is considerable, but this may be replaced by tough fiber board, such as is used in light extension cases. The boards may be covered with enamel cloth or leather, with flaps for the protection of the specimens in rainy weather. The side flaps should be 10 inches wide and the two end ones 7 inches wide, the latter being held together by a strap.

The portfolio should then be filled with thin papers, which when folded should measure $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. Newspaper stock is best for this; in fact, ordinary newspapers cut to this size may be used with advantage. The above sizes should be maintained as a maximum in order that the resulting specimens shall not be larger than the standard mounting sheet, which is $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. The unused sheets can be kept in place and easily slid from under the flaps on one side of the portfolio as needed, the flaps on the opposite side

aiding in holding the filled sheets in position. The strap holding the filled sheets need not be fastened each time a folder is placed under them, as in carrying the portfolio short distances the handles of the portfolio give sufficient pressure to hold the specimens in place. Two portfolios may be carried if many specimens are to be obtained. They will hold all that one person can collect in a day.

The press.—The best form of press (fig. 3) consists of two slat frames, 12 by 17 inches, made from pieces of ash three-sixteenths of an inch thick and three-quarters of an inch wide, the slats to be placed about an inch apart, the ends and all intersections being fastened with

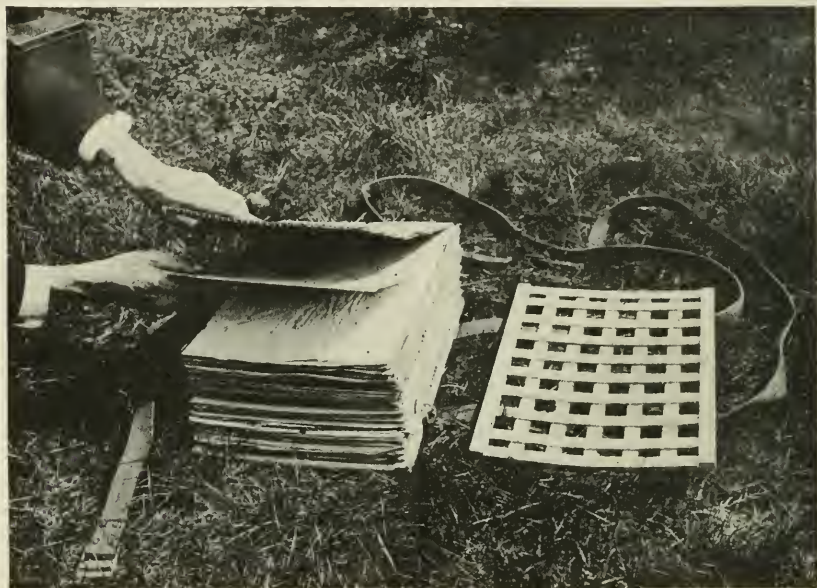


FIG. 3.—A plant press before strapping together, showing construction of the slat frames and the sheets of corrugated cardboard placed between the pairs of driers which separate the folded thin sheets containing the plants.

three or four wire brads, which should be securely clinched. Small rivets may be advantageously substituted for the wire brads in the ends of the strips of wood, since with hard usage the wire brads are more likely to pull out. The driers should be of heavy gray blotting paper or felt carpet paper, cut $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. Pieces of corrugated strawboard (fig. 3), preferably with both surfaces smooth, cut to $11\frac{1}{2}$ by $16\frac{1}{2}$ inches, with the corrugations running lengthwise, placed between the blotters will be found to be of inestimable assistance in drying the plants. Two ordinary leather trunk straps may be used to secure the necessary pressure. Recent experience has, however, demonstrated that a heavy canvas trunk strap having a

buckle with a flat tongue and corrugated edge is more satisfactory than a leather strap. Solid board presses have been used, but they are more likely to cause a sweating and blackening of the plants on the outside of the bundle.

SPECIAL DIRECTIONS FOR PREPARING AND DRYING PLANTS.

Herbaceous plants.—All herbaceous specimens (i. e., those without a woody stem) that are not over $3\frac{1}{2}$ feet tall should be collected entire, including root, stem, leaves, flowers, and fruit when available.



FIG. 4.—A specimen placed between thin sheets, showing the method of folding a tall plant before pressing.

When the stem of a plant is too long to go into the sheets it should be folded into 12 or 15 inch lengths, beginning at the root end to fold (fig. 4). The folds may be held together by strips of thick paper about 1 by 3 inches, with a slit in the middle, the folded ends being inserted through the slit. When herbaceous specimens are over $3\frac{1}{2}$ feet tall it is rarely necessary to collect the whole plant. The height of the plant should be noted on the folder or in a notebook and placed on the label of the plant when it is mounted. Many tall specimens are too thick at the base to be collected entire. In such cases a piece

of the top of the plant about 15 inches long should be collected, together with leaves from the middle or base of the stem, showing the maximum size and any variation in shape. If the root is bulbous or thick and fleshy it should be split in the middle, and if necessary to further reduce the thickness (which preferably should not be over one-fourth of an inch) the inner portion may be scooped out with a knife. All dirt should be removed from the roots and the specimen should be laid out smoothly in one of the folders and placed under the flaps on the side of the portfolio reserved for this purpose.

Woody plants.—A branch from a woody specimen bearing leaves and flowers, or fruit when obtainable, should be about 12 to 15 inches long. Sterile shoots and suckers bearing leaves should be collected when the leaves differ from those of the flowering branches.

Aquatic plants.—Some aquatic plants will stick to the thin drying sheets so that they can not be removed without injuring the specimen. These should be placed in clean water and floated out on a piece of clean white paper that can finally be attached to the mounting sheet, placed in one of the thin driers, and the plant covered with a piece of the finest mesh white cheesecloth or unbleached cotton cloth. When dry this can with care be peeled off without injuring the specimen.

Succulent plants.—Some plants of the orpine family are very difficult to dry perfectly under ordinary conditions, and after they are apparently dried they have been known during damp weather to send out shoots while in the herbarium. This may be prevented by immersing the plant for a few seconds in boiling water to kill the tissues before it is put in the press. Fleshy plants of the cactus family may be treated in the same way if the joints are to be preserved in boxes. Excellent specimens are also made by splitting the joints laterally, scraping out the inside, and pressing the halves.

Seed.—Small quantities of seed may be collected in strong manila envelopes. For larger quantities, bags made from cheesecloth or cheap cotton cloth may be used. It is very desirable in collecting seed that a herbarium specimen from the same plant as the seed be collected to assist in a correct identification, the seed and specimens being given the same number as soon as collected. If possible the specimen should be preserved in some herbarium where it can be consulted should any question arise as to the identification of the seed.

Pressing and drying.—Upon returning from a collecting trip, the plants in the folded sheets should be put in press as soon as possible. They will, however, remain in very good condition in the portfolio as long as 12 or 18 hours. Two driers should be placed between the

folders containing the plants, and, if the plant is very fleshy, three or four driers may be used to advantage.

When the corrugated pieces of strawboard previously referred to are used, only one drier should be placed between it and the folder containing the specimen (fig. 3). The straps should then be adjusted around each end of the press and pulled up as tight as practicable without crushing the plants. Subsequent drying and contraction of the plants may release the tension of the straps and this should be readjusted once or twice during the first day or two. The press full of plants should be kept in a dry place, and, when corrugated boards are not used, the driers should be changed every day for the first three or four days, and then every other day until the plants are dry. Corrugated boards are not of much value in damp weather unless artificial heat is used for drying the plants. The damp driers when removed from the press may be dried in the sun or near a stove. When



FIG. 5.—A folding camp stove set up and a plant press suspended above it for artificial drying.

the corrugated boards are used and the press is placed in a dry sunny situation, or if artificial heat is used, the driers need not be changed at all. The specimens will be thoroughly dry in two to four days.

Artificial drying.—On extended field trips much difficulty is often experienced in drying the plants during damp or rainy weather. To

avoid this difficulty a small folding camp stove¹ made of sheet iron and using wood for fuel may be used and the plant press suspended from the limb of a tree (fig. 5) or from a tripod of green saplings. The press should be 18 inches or 2 feet above the stove. These stoves can be set up inside a tent, the tent being protected from the funnel by an asbestos ring designed for this purpose by dealers in camp outfits, or in the absence of a tent a few boards or even a thatched roof can be arranged to shelter the press from rain. Stoves with liquid fuel are less satisfactory, apparently because of the amount of water vapor in the heated air, the plants drying more slowly and showing more tendency to blacken than with dry heat.

An electric heater with a round disk about 6 inches in diameter has been found satisfactory when the drying is done indoors and electric current is available. The press may then be supported on a frame, or even hung under a camera tripod and driers set on edge around the legs to aid in retaining the heat. The press can also be suspended along an ordinary cooking range, or even placed back of the range with equally good results. Care should be taken in all forms of artificial heating to prevent the plants nearest the source of heat from becoming too hot, as such heating will cause them to sweat and blacken. The position of the press should be changed occasionally, so that all sides may be equally dried. Those fearing to injure the plants by artificial heat will at least find a heating apparatus invaluable in drying the driers. In a dry, sandy, or desert region when the sun is shining the driers will dry very rapidly if laid on the ground, and in such situations it is preferable to lay the plants out on the ground between the driers when the latter are to be dried. An elastic band slipped over each end will prevent them from being blown about, and they should be turned over two or three times at short intervals. As soon as the driers are dry they should be returned to the press, to prevent the plants from becoming wrinkled.

ABBREVIATED DIRECTIONS FOR PREPARING SPECIMENS.

Those wishing to prepare only an occasional specimen to send to the Department for identification can make them of the size indicated on page 29 and press them between pads consisting of several thicknesses of newspaper. These pads should be changed daily as long as they are damp, and a board with a few bricks or heavy books may be used for a weight.

PREPARATION OF DATA.

All specimens should be accompanied by a statement showing the locality, date, and place of collecting and the collector's number.

¹ These may be obtained from dealers in campers' supplies.

The locality should be so definite that the spot can be revisited if necessary. A plan of the immediately surrounding region may advantageously be made in the notebook to aid in relocating individual plants. Notes should be made of the habit and size of the plant, particularly when the whole plant is not collected. The data should be written on the sheet in which the plants are pressed or on a temporary label provided for the purpose, or, if more convenient, the sheets may be numbered and the data all entered in a notebook at the time the specimens are collected. Specimens for identification should be prepared in duplicate, both given the same number, and one sent with full data, the determinations being returned by number. Great care should be taken that all specimens bearing the same number are specifically identical or are from the same plant, as much confusion has been caused by collectors distributing two or more species under the same number. For convenience in citation by publishing botanists, those making herbaria of their own or who are collecting plants for distribution should number all their collections consecutively from 1 upward and should not begin at 1 each year, as this often leads to confusion. A field notebook should also be kept, in which is a list of the numbers, followed by the names when the plants have been identified, the date and place of collecting, the altitude when from mountains, and the habitat and kind of soil in which they grew. Cultivated specimens should be accompanied by data as to the native country or trade firm from which the specimens or seeds were originally received. It is also important that any local or trade name should be given when known, together with any economic uses of the plant. A plain label about $1\frac{7}{8}$ by 4 inches, bearing such data as necessary, is preferable, with the region in which they were collected printed at the top, as "Plants of Arizona." If many labels are to be written, other data may be printed to save time.

SHIPPING SPECIMENS.

Pressed and dried specimens should be shipped in the thin sheets in which they were collected, and the bundle of sheets placed between pieces of binder's board or heavy cardboard and securely wrapped and tied. Where it is impracticable to make a good herbarium specimen of the plant, the specimen should be carefully wrapped in damp sphagnum moss and inclosed in oiled or paraffin paper. If these materials are not available, moistened newspapers may be used for wrapping the plants and the package then inclosed in stout wrapping paper. Packages to be sent by parcel post must not exceed 11 pounds in weight or 72 inches in length and girth combined.

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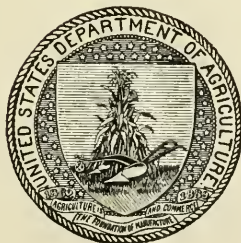
BUREAU OF PLANT INDUSTRY—Circular No. 127.

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

The Work of the Delta Experiment Farm in 1912	JOHN P. IRISH, JR.
Silver Scurf, a Disease of the Potato	I. E. MELHUS
The Dasheen, a Root Crop for the Southern States	ROBERT A. YOUNG

Issued May 17, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, WILLIAM A. TAYLOR.

Assistant Chief of Bureau, L. C. CORBETT.

Editor, J. E. ROCKWELL.

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[Cir. 127]

THE WORK OF THE DELTA EXPERIMENT FARM IN 1912.¹

By JOHN P. IRISH, JR., *Farm Superintendent, Office of Western Irrigation Agriculture.*

INTRODUCTION.

DESCRIPTION OF THE REGION.

The Delta Experiment Farm is located on the Lower Jones Tract, one of the islands in the south-central portion of the San Joaquin Delta. The tract is typical of the general San Joaquin Delta lands. The soil is a very light peat, characteristic of most of the reclaimed land on the San Joaquin side of the delta.

These lands lie at sea level and before their reclamation were flooded during the major portion of the year. The delta of the combined Sacramento and San Joaquin rivers occupies an aggregate area of about 250,000 acres.

Reclamation is accomplished by leveeing to exclude tidal and flood waters and by the installation of ditches and pumps discharging into the river to furnish drainage and control the ground-water level. The drainage system consists of main drainage ditches or canals from 18 to 30 feet wide and from 7 to 12 feet deep, into which empties a secondary system of hand-dug ditches 3 to 4 feet wide and 4 to 6 feet deep. These secondary ditches divide the land into blocks or fields of from 10 to 100 acres, the average unit being 50 acres.

Since the rainfall of the section averages only about 15 inches per year, irrigation is necessary for the production of crops. The secondary ditch system is used both for drainage and as head ditching for irrigation, the water being drawn into it from the river channels by means of siphons over or headgates through the levees.

The climate is mild, and plant growth is continuous throughout practically the entire year. This somewhat complicates the problem of controlling weeds and plant diseases, the latter being specially difficult to eradicate because of the continuous growth of many of the host plants.

¹ Issued May 17, 1913.

The Delta Experiment Farm was established in 1911 at Middle River, 14 miles west of Stockton, Cal., on a tract of land comprising about 100 acres provided by the Delta Association of California. This association is composed of farmers who are operating in the delta region, and the organization cooperated with the Bureau of Plant Industry in the work here reported. The University of California is also conducting investigations on the same tract, about 50 acres being used for this purpose. Actual operations were begun in the spring of 1912. The work in which the Bureau of Plant Industry was directly concerned in 1912 was devoted to experiments with potatoes. This work was under the immediate supervision of Mr. John P. Irish, jr., who was detailed from the Bureau of Plant Industry.

CROPPING SYSTEMS.

The principal crops grown are potatoes, barley, beans, and onions. A large acreage is also devoted to asparagus, and celery is grown to some extent. The principal cash crop of the region is potatoes, 52,000 acres being devoted to this crop in the delta region in 1912. The barley acreage, while large, usually gives a much lower acreage return than potatoes.

The present cropping system on the San Joaquin side of the delta is based principally on a 2-year rotation of potatoes and barley. In many cases tenants holding term leases grow barley hay, beans, and onions instead of barley in alternation with potatoes, but in a majority of cases the barley-potato rotation is the accepted one, the effort usually being to devote as much land to potatoes as possible, although the exigencies of the potato market and the decrease in potato yields sometimes cause individual owners to hold their lands in barley for more than one season in an effort to improve conditions. The lands are farmed largely on an annual tenancy system, the potato tenant moving from farm to farm with the rotation of the crops, while the barley tenant farms each year an aggregate area comprising five or more potato farms. The unit area of potato farming is from 100 to 300 acres.

Potatoes are planted from the latter part of March till early June, the bulk of the planting being done in April and May. The harvest ordinarily extends from the last of September to the first of January, the potatoes being dug as the market requires them.

The land is given a preliminary plowing in the early spring to check the weeds and improve the soil tilth and is then allowed to lie from one to three months. Planting is done while plowing, the seed being dropped by hand in the alternate furrows. The seed piece is commonly cut to two eyes. The spacing is from 30 to 32 inches between the rows and 8 to 12 inches between hills, giving about 20,500 plants to the acre as a maximum stand. The ground is harrowed from one to three times before the plants are large enough to be damaged. When the plants are large enough to define the rows, ditches 10 inches wide with an average depth of 18 inches are cut between two rows 60 to 70 feet apart. Water is later run into these ditches from the head ditches, regulated to fill them nearly full, and irrigation is accomplished by lateral percolation. Three to five irrigations are given during the growing season, the number depending on the soil and climatic conditions and the height of the ground-water table. The crop is given one or two hand hoeings, one to three cultivations, and one hilling. Harvesting is done by hand with potato hooks, the sorting being done during the digging, the culls usually being left in the field. This method, while tedious,

expensive, and rather wasteful, is made necessary by the physical peculiarities of the peat soil, in which no machine digger so far tried has done effective work.

PREVIOUS INVESTIGATIONS.

Progressive decrease in potato yields and a lowering of quality under the present methods of cropping led to an investigation of the potato situation in 1908 by the Office of Cotton and Truck Disease and Sugar-Plant Investigations of the Bureau of Plant Industry, and the results were published in 1909.¹ These results seemed to indicate that the decrease in yield and quality was due largely to pathological conditions. Some preventive measures were described, but it was stated that further investigation was necessary, particularly in connection with the improvement of cropping systems and cultural methods.

EXPERIMENTS WITH POTATOES IN 1912.

In the spring of 1912 work was begun by the Office of Western Irrigation Agriculture looking to the improvement of cropping methods on these lands. Since potatoes are the crop upon which the landholders depend for maximum returns, their place and duration in any rotation are of great importance. In the work for the crop season of 1912 the main aim was to determine what method of tillage, fertilization, and rotation may be expected to give the best results in potato production and weed control.

It was thought that the potato wilt might be controlled by increasing the vigor of the plants and that the damage from scab might be reduced by acidulating the soil. For this reason the experiments included methods of stimulating plant growth, particularly through the use of commercial fertilizers, and also included methods of acidulation. The Burbank variety was used in all the trials.

The land used in 1912 comprised about 32 acres in three fields (fig. 1), as follows: Field F, 15.5, field G, 6.6, and field I, 10 acres. This land had been planted to potatoes in 1911 and was very weedy when taken over for experimental purposes.

In most of the experiments determinations were made of the stand, the extent of potato wilt (*Fusarium oxysporum*), the extent of scab, a disease due to a fungus (*Oospora scabies*), and the yield of marketable tubers and of tubers of unmarketable sizes. The method followed in these determinations and the meaning of the figures used in the following tables are described later.

¹ Orton, W. A. Potato Diseases in San Joaquin County, Cal. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 23, 14 p., 1909.

During the growing season a count was made of the actual stand on the plats, and during the latter part of September a count was made of the wilted plants. In tabulating the results of these counts the percentage of stand was determined by computing the percentage

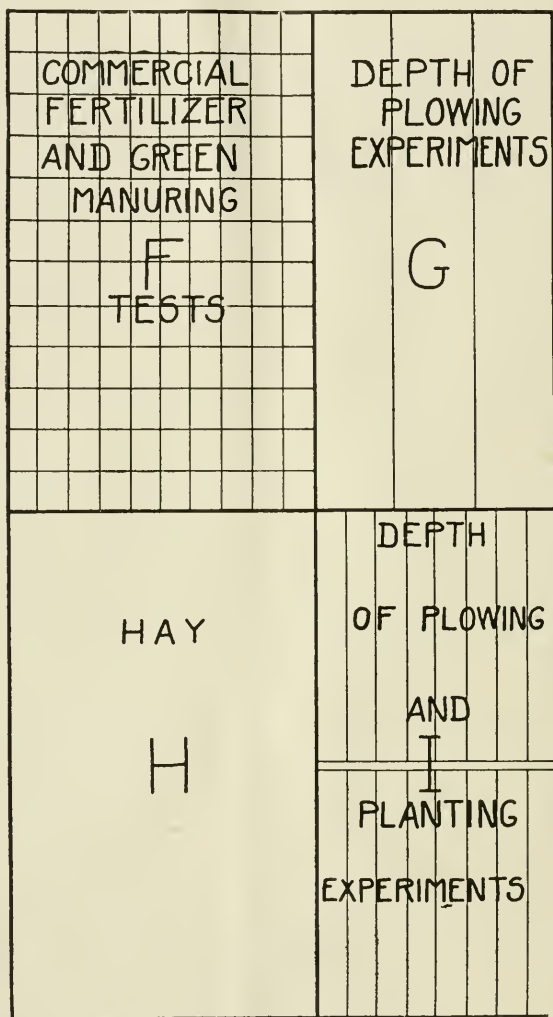


FIG. 1.—Diagram showing the fields used in the experiments with potatoes at the Delta Experiment Farm in 1912.

of a perfect stand, estimated by the distance between rows and hills on each plat; the potatoes having been planted at the usual distances as described above, a stand of 20,500 plants per acre was taken as 100 per cent. The percentage of wilt was computed as the ratio between the wilted plants and the actual stand.

In October and November a sample digging was made of four rows equidistant across each plat. In this digging all the potatoes in each hill were gathered, regardless of size or condition, and a sorting was made in which all potatoes of marketable size and in marketable condition were segregated, weighed, and classed as marketable. The culls were then sorted and weighed, being classed as undersized or scabby. The undersized scabby potatoes were classed as undersized, and only the potatoes which but for the scab would have been marketable were classed as scabby. In computing the results of the sample digging, the percentage of scab and unmarketable sizes was determined in terms of the marketable potatoes obtained in this digging, and the results were taken as being representative of the plat as a whole.

In December and January the final digging of marketable potatoes was made, and this yield when added to the marketable potatoes obtained during the sample digging and computed to an acreage yield is carried in the tables as the market yield.

TESTS OF TILLAGE METHODS WITH GREEN MANURE AND COMMERCIAL FERTILIZERS.

Alternate lands in field F were plowed 6 inches and 12 inches deep, respectively, in February. The north half of the alternate pairs was sown to vetch early in March, and the south half of the same pair was sown to barley. Certain blocks of these lands were treated with commercial fertilizers. The vetch made very little growth, but the barley reached a height of 15 to 18 inches by the middle of May, when the lands were replowed.

In addition to the fertilizers applied in March on certain of the green-manured and bare plats, fertilizer was applied in the rows of potatoes on certain other of the green-manured and bare plats at planting time, early in June. The fertilizers used in both cases were K_2SO_4 (potassium sulphate), KCl (potassium chlorid), and $CaHP_2O_6$ (superphosphate). All were very high grade. All planting on field F was at a depth of 6 inches. The results of this test are given in Table I, together with comparisons of the results obtained with the same green manures and tillage methods but without the use of commercial fertilizers.

For convenience in comparing averages, the data are given in condensed form at the close of the table where the averages of all the results obtained with commercial fertilizers are compared with the results secured on the unfertilized plats.

TABLE I.—Results obtained with various tillage methods and with various commercial fertilizers at the Delta Experiment Farm in 1912.

Fertilizer (applied at 140 pounds per acre).	Item.	Tillage methods with green and artificial manures.						Average of all tillage methods.		Tillage methods and green manure without commercial fertilizers.				
		Fertilizers applied in March.			Fertilizers applied when planting.			With out commercial fertilizer.	With out commercial fertilizer.	Deep plowed.		Shallow plowed.		
		Deep plowed.		Shallow plowed.	Deep plowed.		Shallow plowed.			Green manure. ³	Bare. ⁴	Green manure. ³	Bare.	
		Green manure. ¹	Bare. ²		Green manure. ¹	Bare. ¹	Green manure. ¹							Bare. ¹
Superphosphate.	Stand.....per cent.	37.0	31.8	34.1	28.9	25.2	27.0	29.1	31.3	29.5	31.0	34.7	30.0	
Do.....	Marketable yield, ⁵ pounds..	93.0	84.5	75.0	75.3	67.0	58.0	76.0	74.5	79.0	70.0	75.0	74.0	
Do.....	Unmarketable:	9,330	8,503	7,235	7,330	4,581	4,827	6,752	6,607	7,939	6,445	5,772	6,272	
Do.....	Undersized.....per cent.	23.5	25.0	21.9	22.1	20.8	56.3	38.8	22.9	21.4	24.2	25.5	20.5	
Do.....	Scabby.....do.....	8.2	13.9	2.2	5.3	10.0	2.9	1.3	6.4	5.5	6.4	4.7	5.7	
Potassium chlorid.	Stand.....do.....	38.0	30.2	32.1	31.3	15.9	25.4	25.1	27.4	31.3	31.0	34.7	30.0	
Do.....	Marketable yield, ⁵ pounds..	83.0	76.0	82.0	82.0	53.0	55.0	17.5	59.8	74.5	64.5	75.0	74.0	
Do.....	Unmarketable:	9,505	7,253	6,245	6,528	3,764	4,875	3,697	6,208	6,607	6,445	5,772	6,272	
Do.....	Undersized.....per cent.	17.6	18.1	15.4	17.0	27.2	27.7	36.4	23.4	22.9	24.2	25.5	20.5	
Do.....	Scabby.....do.....	2.7	3.9	4.2	5.0	13.1	2.9	0	4.6	5.5	6.4	4.7	5.7	
Potassium sulphate.	Stand.....do.....	39.0	30.1	30.7	29.1	16.3	26.9	22.7	27.9	31.3	31.0	34.7	30.0	
Do.....	Marketable yield, ⁵ pounds..	82.0	83.3	72.0	72.3	54.0	41.0	51.0	65.9	74.5	64.5	75.0	74.0	
Do.....	Unmarketable:	9,232	7,365	8,355	7,001	4,212	3,677	4,120	6,244	6,607	6,445	5,772	6,272	
Do.....	Undersized.....per cent.	10.2	12.8	12.6	14.5	38.3	29.0	38.6	24.8	22.9	24.2	25.5	20.5	
Do.....	Scabby.....do.....	0	3.1	6.1	8.1	1.7	2.9	5.2	4.0	5.5	6.4	4.7	5.7	

Fertilizer.	Item.	CONDENSATION AND COMPARISON.						Average of 9 plats.		Average of 6 plats.		Average of 3 plats.		Per acre.
		Deep plowed.		Shallow plowed.	Deep plowed.		Shallow plowed.		With out commercial fertilizer.	With out commercial fertilizer.	Green manure. ³	Bare. ⁴	Green manure. ³		Bare.
With fertilizer.	Stand.....per cent.	38.0	30.7		32.3	29.7	25.7	19.1						26.4		25.6	28.4	31.3	34.7	30.0
Without fertilizer.	do.....do.....	29.5	31.0	34.7	30.0	29.5	31.0	34.7	30.0	28.4	31.3	34.7	30.0	
With fertilizer.	Marketable yield per acre, pounds.	86.0	81.2	76.3	68.3	69.6	58.0	51.3	48.1	67.3	74.5	74.0	75.0	
Without fertilizer.	do.....do.....	79.0	70.0	75.0	74.0	79.0	79.0	74.0	74.0	67.3	74.5	74.0	75.0	
With fertilizer.	Marketable yield per acre, pounds.	9,355	7,707	7,271	6,953	8,122	4,185	4,459	4,856	6,612	6,007	6,007	6,272	
Without fertilizer.	do.....do.....	7,939	6,445	5,772	6,272	7,939	6,445	5,772	6,272	6,007	6,007	6,007	6,272	
With fertilizer.	Undersized.....per cent.	17.1	18.6	16.6	17.8	32.7	28.7	37.6	37.8	25.8	22.9	22.9	25.8	
Without fertilizer.	do.....do.....	21.4	24.2	25.5	20.5	8.5	5.5	2.9	2.9	4.9	5.5	5.5	4.9	
With fertilizer.	Scabby.....do.....	3.6	6.6	4.1	3.7	8.5	5.5	2.9	2.9	4.9	5.5	5.5	4.9	
Without fertilizer.	do.....do.....	3.1	6.4	4.7	3.7	3.1	6.4	4.7	4.7	5.7	5.5	5.5	4.9	

1 One plat.

2 Average of 3 plats.

3 Average of 6 plats.

4 Average of 9 plats.

5 Per acre.

CONDENSATION AND COMPARISON.

Fertilizer.	Tillage method.	Average of 3 plats.						Average of 6 plats.						Average of 9 plats.					
		Stand.	Wilt.	Marketable yield, ⁵ pounds.	Unmarketable.	Undersized.	Scabby.	Stand.	Wilt.	Marketable yield, ⁵ pounds.	Unmarketable.	Undersized.	Scabby.	Stand.	Wilt.	Marketable yield, ⁵ pounds.	Unmarketable.	Undersized.	Scabby.
With fertilizer.	Do.....	38.0	30.7	32.3	29.7	25.7	19.1	26.4	25.6	28.4	31.3	22.9	24.8	28.4	31.3	22.9	24.8	22.9	24.8
Without fertilizer.	Do.....	29.5	31.0	34.7	30.0	29.6	31.0	34.7	30.0	30.0	31.3	22.9	24.8	28.4	31.3	22.9	24.8	22.9	24.8
With fertilizer.	Do.....	86.0	81.2	76.3	68.3	69.5	58.0	51.3	48.1	67.3	74.5	6.6	6.4	67.3	74.5	6.6	6.4	6.6	6.4
Without fertilizer.	Do.....	79.0	70.0	75.0	74.0	75.0	70.0	75.0	74.0	74.0	74.5	6.6	6.4	67.3	74.5	6.6	6.4	6.6	6.4
With fertilizer.	Do.....	9.355	7,707	7,271	6,953	8,122	4,185	4,559	4,856	6,612	6,607	5.5	5.7	6,612	6,607	5.5	5.7	5.5	5.7
Without fertilizer.	Do.....	7,939	6,445	5,772	6,272	7,939	6,445	5,772	6,272	6,272	6,607	5.5	5.7	6,612	6,607	5.5	5.7	5.5	5.7
With fertilizer.	Do.....	17.1	18.6	16.6	17.8	32.7	28.7	37.6	37.8	25.8	22.9	4.9	4.7	25.8	22.9	4.9	4.7	4.9	4.7
Without fertilizer.	Do.....	21.4	24.2	25.5	20.5	8.5	5.5	2.9	2.1	4.9	5.5	4.7	5.7	25.8	22.9	4.9	4.7	4.9	4.7
With fertilizer.	Do.....	3.6	6.6	4.1	6.1	5.1	6.4	5.5	2.1	4.9	5.5	4.7	5.7	25.8	22.9	4.9	4.7	4.9	4.7
Without fertilizer.	Do.....	5.1	6.4	4.7	5.7	5.1	6.4	5.5	2.1	4.9	5.5	4.7	5.7	25.8	22.9	4.9	4.7	4.9	4.7

The results of various methods of tillage and green manuring and the same methods with applications of potassium sulphate, potassium chlorid, and superphosphate show some significant differences. The most notable of these is the rather uniformly higher yields with superphosphate under all conditions of tillage and the uniformly better yields in proportion to stand which were obtained by applying the fertilizer in March over applying fertilizers at planting time. Deep plowing showed better results than shallow, and green manure gave generally better yields than were obtained from the bare fields.

THE USE OF VARYING QUANTITIES OF SUPERPHOSPHATE.

An experiment was conducted to determine the effect of applying superphosphate at different rates on land to which various tillage methods were applied. Each of the eight plats used in the experiment contained one-tenth of an acre. The results are given in Table II.

TABLE II.—*Results obtained with potatoes on land treated with varying quantities of superphosphate at the Delta Experiment Farm in 1912.*

	Treatment.							
	Plowed 12 inches deep.				Plowed 6 inches deep.			
	Green manure.		Bare.		Green manure.		Bare.	
Superphosphate per acre.....pounds..	600	1,200	600	1,200	400	800	400	800
Stand.....per cent..	34.7	34.0	31.7	38.7	44.9	36.3	36.3	33.6
Wilt.....do.	97.0	81.0	75.0	50.0	84.0	77.0	77.0	80.0
Marketable yield per acre.....pounds..	8,805	7,105	10,402	9,030	8,575	8,105	9,360	8,555
Unmarketable:								
Undersized.....per cent..	21.9	15.3	12.9	20.9	23.6	18.6	21.7	39.8
Scabby.....do.	8.0	2.4	2.6	4.5	11.8	9.9	10.3	11.1

It is seen from Table II that varying the rates of superphosphate application resulted in no consistent differences in yield. The growth of haulm, however, was noticeably increased by the heavier application.

ACIDULATION OF IRRIGATION WATER.¹

With a view to studying the effect of acidulating the irrigation water on the growth of potatoes and more particularly on the action of the scab organism, *Oospora scabies*, an experiment was conducted on four tenth-acre plats in field F. Commercial sulphuric acid was used. The method used consisted in the placing of a plank 10 inches wide and 6 feet long in the ditch at the head of each plat, the

¹This work was planned in accordance with suggestions of Mr. Karl F. Kellerman, Physiologist in Charge of the Office of Soil-Bacteriology and Plant-Nutrition Investigation.

plank being pegged with the upper end 2 inches under water and with a fall of 4 inches to its length. Carboys containing a weighed quantity of acid were placed at the head of each plank with stoppers arranged to drop the acid at a rate designed to empty the carboys in six hours. A green-manure crop was plowed under on all the plats in early spring. The acid applications were made at the time when the tubers were beginning to form. The results are given in Table III.

TABLE III.—*Results of acidulation of irrigation water on potatoes at the Delta Experiment Farm in 1912.*

	Depth of plowing.			
	12 inches.	6 inches.	12 inches.	6 inches.
Rate of acid application per acre.....pounds..	500	500	900	900
Stand.....per cent..	32.3	31.4	30.9	36.8
Wilt.....do..	58.0	69.0	64.0	70.0
Marketable yield per acre.....pounds..	5,212	5,992	4,247	5,622
Unmarketable:				
Undersized.....per cent..	13.4	24.2	18.5	31.8
Scabby.....do....	10.6	7.2	9.4	4.4

While the results of acidulation show no increase in yield or reduction in scab, they give other indications which are of interest. These applications were made when the tubers were beginning to form, so that the percentage of stand has no relation to the application of acid. The immediate effect of the acid was a marked increase in the vegetative vigor of the plants. This stimulation continued during the remainder of the growing period, so that at harvest time the haulm was double that of any other plats in the field. The wilt infection on these plats was not only uniformly lower than on the rest of the field, but the growth of the infected plants was much less depressed. When the infected haulms on the rest of the field were dead, the infected plants on the acid-treated plats were still alive and with a large portion of their total leaf area green. These results, taken in conjunction with the lateness of the application, the moderate price of sulphuric acid, and the ease of application, suggest a promising field for further work.

DEPTH-OF-PLOWING TEST.

An experiment to test the effect of plowing at varying depths was conducted on field G. The plowing was done in March, the depths being 6, 12, and 18 inches. The potatoes were planted in June at a uniform depth of 6 inches. Each part of the experiment was duplicated on quarter-acre plats, so that each result given in Table IV is the average of two plats.

TABLE IV.—*Results obtained with potatoes at three different depths of plowing at the Delta Experiment Farm in 1912.*

		Depth of plowing.		
		6 inches.	12 inches.	18 inches.
Stand.....	per cent.....	30.6	28.6	29.4
Marketable yield per acre.....	pounds.....	4,370	5,405	5,978
Unmarketable:				
Undersized.....	per cent.....	22.5	17.7	16.7
Scabby.....	do.....	5.3	7.2	5.6

The yields, as shown in Table IV, increased with the depth of plowing, but the difference between the 12 and 18 inch plowing was probably not enough from the standpoint of one season's yield alone to justify the added expense of the 18-inch plowing.

DEPTH-OF-PLANTING TEST.

On field I an experiment in depth of planting in connection with two depths of plowing was tried. Alternate lands were plowed, respectively, 6 and 12 inches deep in March, and potatoes were planted in June, 4 and 8 inches deep on each kind of plowing. Eight half-acre plats were used in this test. The yields of marketable tubers per acre are shown in Table V.

TABLE V.—*Yields of marketable potatoes obtained from planting at different depths at the Delta Experiment Farm in 1912.*

	Treatment.							
	Plowed 12 inches deep.				Plowed 6 inches deep.			
	Green manure.		Bare.		Green manure.		Bare.	
Depth of planting.....inches..	4	8	4	8	4	8	4	8
Yield per acre.....pounds..	6,822	5,610	7,055	7,096	3,264	4,091	5,502	7,057

It is seen that with shallow plowing deep planting gave better results than shallow planting and that the results on the deep-plowed plats were contradictory.

COMPARISON OF LOCAL AND IMPORTED SEED.

Conditions for storing seed potatoes in the delta region are ordinarily not favorable. As there are no facilities for cold storage or for storing in pits, seed carried over from harvest to planting time is frequently weakened by sprouting. In order to determine the effects produced by using locally grown seed as compared with those resulting from the use of seed of the same variety shipped in from Oregon

at planting time, an experiment with the two classes of seed was conducted on 22 tenth-acre plats. The seed imported from Oregon had been stored there in pits during the winter of 1911-12. Four plats of this seed were planted, two on land plowed 6 inches deep and two on 12-inch plowing. In the same series, nine plats plowed 6 inches deep and nine plats plowed 12 inches deep were planted to locally grown seed. The results are given in Table VI.

TABLE VI.—*Results obtained with potatoes grown from Oregon seed and from locally grown seed at the Delta Experiment Farm in 1912.*

	Oregon seed.		Locally grown seed.	
	Deep plowed.	Shallow plowed.	Deep plowed.	Shallow plowed.
Stand.....per cent..	39.1	37.4	31.0	30.0
Wilt.....do....	83.0	81.5	70.0	74.0
Marketable yield per acre.....pounds..	10,204	9,440	6,445	6,272
Unmarketable:				
Undersized.....per cent..	37.6	15.6	24.2	20.5
Scabby.....do....	5.1	6.6	6.4	5.7

Table VI shows the differences in yield between pit-stored Oregon seed, sound and unsprouted, shipped in at planting time, and local seed weakened by sprouting. The yield from Oregon seed was decidedly higher and the stand was better. It is also noticeable that deep plowing again gave better results than shallow plowing.

SUMMARY.

The work conducted on potatoes at the Delta Experiment Farm in 1912 resulted in several important indications. Some of the more prominent facts noted are the following:

(1) Of the three commercial fertilizers used, superphosphate was the only one which markedly increased the average yields as compared with those obtained from the unfertilized plats.

(2) Better average results were obtained from the use of commercial fertilizers when the application was made in March than when the fertilizer was applied at planting time, in June.

(3) Plowing under a green-manure crop of barley resulted in increased average yields.

(4) The yields were generally better on 12-inch plowing than on 6-inch plowing.

(5) No consistent yield differences were obtained where superphosphate was applied in varying quantities. The growth of haulm, however, was increased by the heavier applications.

(6) Acidulation of the irrigation water with sulphuric acid resulted in no appreciable reduction in the action of potato scab and no in-

crease in yield, but the vegetative vigor of the plants and their resistance to wilt were markedly increased.

(7) In the test of 6, 12, and 18 inch plowing the yield increased with the depth, but the difference between the 12-inch and the 18-inch plowing was not sufficient to justify the added expense of the latter.

(8) On the shallow plowed land 8-inch planting gave higher yields than 4-inch planting, but no consistent difference in yield was noted on the deep-plowed land.

(9) Decidedly higher yields were obtained from sound Oregon seed than from locally grown seed, the difference appearing to be due to the deterioration of the locally grown seed resulting from improper storage.

(10) With the exception of the plats treated with sulphuric acid no consistent differences were shown in the wilt percentages, nor were any consistent differences shown in the scab percentages.

(11) One significant feature of the season's work was the uniformly thin stand on the fields. An examination of the plats following planting time showed that the decrease in stand on the old land was due to the very rapid rotting of the seed in the ground. The investigations along this line during the crop season of 1912 lead to the conclusion that the rotting of the seed pieces, resulting in thin stands and weak plants, is perhaps the most important factor causing decrease of yield.

SILVER SCURF, A DISEASE OF THE POTATO.¹

By I. E. MELHUS, *Pathologist, Cotton and Truck Disease and Sugar-Plant Investigations.*

INTRODUCTION.

It seems desirable to call the attention of potato growers to a disease of the potato which, though little known, is becoming widespread in the United States. This is the silver scurf, a tuber trouble caused by a species of *Spondylocadium* which attacks and destroys the periderm, causing discoloration and loss of moisture. According to information in hand it seems to have secured a foothold throughout the Eastern States without its presence being generally recognized. Introduced in all probability from Europe, it has spread rapidly and will have to be reckoned with as one of the factors in the deterioration of this crop. While the inconspicuous appearance of silver scurf has permitted it to be overlooked, it can readily be recognized after a little experience, and everyone interested should learn to distinguish this disease from the several others which occur on potato tubers.

APPEARANCE OF DISEASED TUBERS.

Silver scurf in its early stages of infection under moist conditions causes blackish olive patches on the surface of the potato, which may, and often do, cover considerable areas. This more or less superficial growth is the brown-mold stage and consists of the conidiophores and conidia of the fungus. This stage is well shown in figure 1. In the later stages of the development of the disease small black sclerotia are formed on the infected areas instead of the superficial growth of conidiophores. The surface of the discolored areas when clean takes on a silvery or glistening appearance, which is due to the raising of the cells of the outer layers by the mycelium of the fungus. This disfiguration of the surface is later followed by depressed patches of greater or less extent. The early stages in the formation of such spots are shown in figure 2, while the late stages are evident in figure 3. As the disease progresses the infected areas increase in diameter and the fungus penetrates deeper into the tuber. As a result it is not uncommon to find the whole surface of a tuber discolored, shrunk, and shriveled like the lower tuber in figure 3, while the outer layers of the periderm are loose and sloughing off.

¹ Issued May 17, 1913.

DESCRIPTION OF THE FUNGUS.

The fungus causing silver scurf has two more or less markedly distinct stages in its development: The brown-mold stage (fig. 1, *a*, *b*, and *c*), which appears first and consists of the conidiophores and conidia, and the sclerotial stage, which follows later and consists of numerous small black sclerotia buried in the outer cells of the dis-

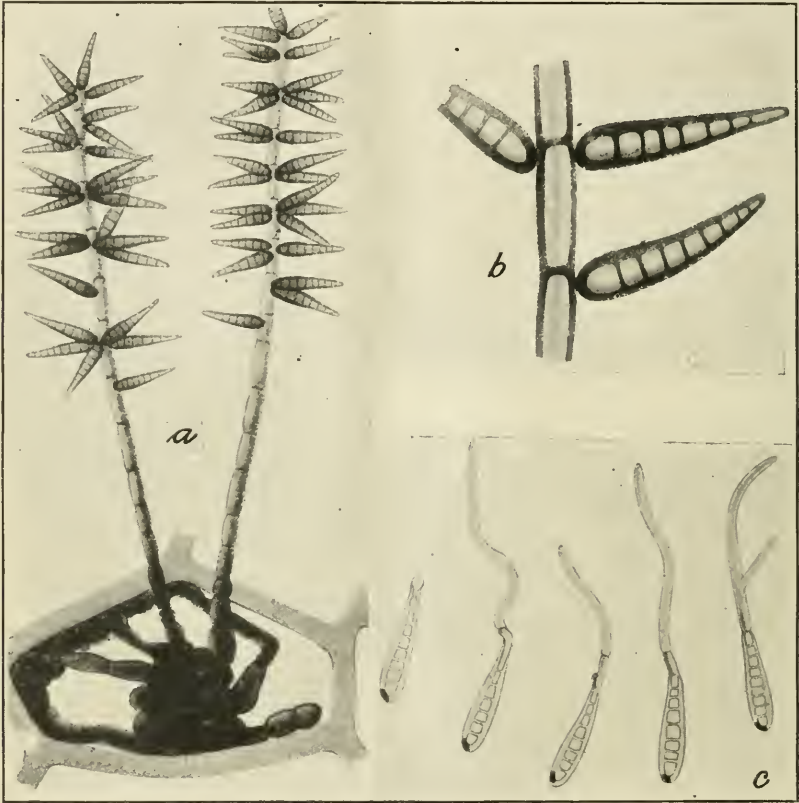


FIG. 1.—The brown mold stage of *Spondylocladium Atrovirens*. (*a*) The fruiting organs of the fungus. (*b*) A portion of conidiophore with attached conidia. (*c*) The several-celled spores, which usually put out a germ tube from the pointed end of the spore. (After Appel and Laubert.)

colored areas. The relation of the sclerotia to the cells of the outer skin of the potato is shown in figure 4. When viable spores are placed in water at room temperature, they push out germ tubes in the manner shown in figure 1, *c*. These may penetrate the periderm and later the parenchyma, according to Frank. It has been reported by Johnson that sclerotia are even produced in the cells of the parenchyma and that the fungus grows readily on the cut surface of the potato. The writer has also observed the fungus fruiting on cut sur-

faces of potatoes. As the fungus spreads in the tissues it loosens the surface layers, causing the white silvery color. Later the surface layers slough off, carrying with them numerous sclerotia that infect the soil. In moist conditions the fungus fruits in from four to five days after the spores have germinated. The conidiophores may spring either from the mycelium in the tissues or from a sclerotium, in the manner shown in figure 1, *a*. The conidiophores are dark brown,



FIG. 2.—Potatoes (Irish Cobbler variety) infected with *Spondyliocladium atrovirens*. The lower right-hand tuber is free from infection, while the other two show successive stages of infection. The diseased areas in this stage of development have not become shrunk and shriveled.

rather tall, being about 120 microns long and 4 microns in diameter. (See fig. 1.) The spores are borne in rather irregular whorls on the upper portion of the conidiophore. The spores are dark brown, obovate, 5 to 7 celled, and about 40 microns in length by 8 in diameter. Nothing is known as to the longevity of the spores or the sclerotia. It is very probable that both are quite resistant and may therefore be important factors in facilitating the spread and continuance of the disease. It has been shown by Eichinger that the germ tubes and mycelium grow from the light, showing a negatively heliotropic reaction.

The sclerotial stage was until recently thought to be due to another fungus called *Phellomyces sclerotiphorus*. Black sclerotia, 8 to 16 microns in diameter, are formed more often in the surface layer of cells (fig. 4), although, according to Johnson, they may also be produced in the deeper layers of the periderm and parenchyma. From this observation it would seem that the fungus is able to attack any part of the tuber, a fact tending to show its parasitic nature.

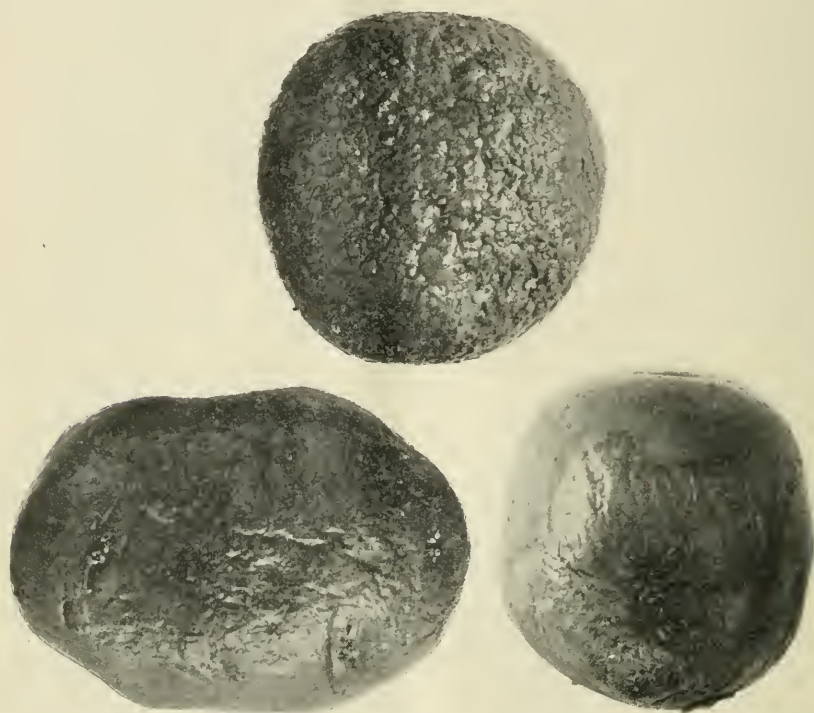


FIG. 3.—Later stages of silver scurf infection in the same variety of potato as shown in figure 2. It is a very common occurrence to find such infections as shown in the lower right-hand tuber. The effect of this disease on the potato is clearly shown in the upper tuber. The surfaces are shriveled, due to the loss of moisture and sloughing off of the protective covering.

The fungus causing silver scurf has been described as *Spondylocladium atrovirens* by Appel and Laubert. The spores are reported to be "4-8 (Meist 6-9) Querwänden, 7, 8-11, 9; 36-61, 5, in Mittel 10:46 μ ." Clinton found that the species he studied had smaller spores. The writer has also found that the spores are not nearly as large as reported by Appel and Laubert. Whether this difference in the size of the spores is sufficient cause for considering the American species different from the European one is not clear at the present time. According to Clinton it has been suggested by Appel that there may be at least two forms, one having larger spores than the other. A study of this matter is in progress.

This disease was called "Fleckenkrankheit" and also "Phellomyces-Faule" by Frank in 1897 and 1898, respectively. It can hardly be considered a spot disease, since it very often involves the whole surface of the diseased tuber. Recently it has been shown by Appel and Laubert that *Phellomyces sclerotiphorus*, the fungus described by Frank, is only the sclerotial stage of *Spondylocladium atrovirens*. This fact naturally excludes the possibility of using the name applied to this disease by Frank. More recently the disease under consideration has been called "scab," "dry rot," "dry scab," and "scurf." It does not seem wise nor justifiable to apply the term "scab" to this disease, since we already have three or four different kinds of scab. Furthermore, *Spondylocladium* does not cause symptoms comparable to those produced by *Oospora*, *Spongospora*, and *Chrysophlyctis*. As is well known, all of these parasites cause hypertrophy and cankers of the tissues infected. Such is not the case with *Spondylocladium*. On the contrary, it causes the death and shrinkage of the attacked cells and tissues. The term "scurf" has been applied by Clinton and is doubtless a better name than any used previously, because it is less confusing and is more descriptive of the symptoms of the disease. The light, glistening, silvery discoloration of the surface of the washed potato due to the *Spondylocladium* infection is a very common and characteristic symptom. In view of this fact the name "silver scurf" is proposed for this disease.

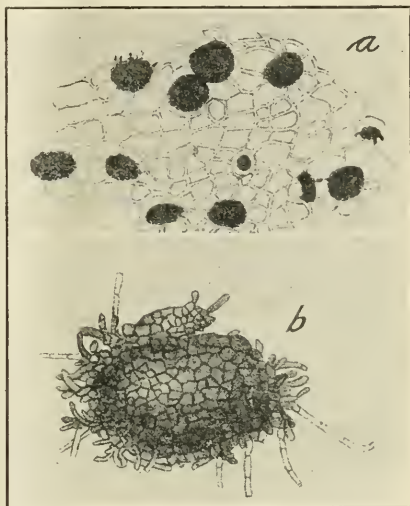


FIG. 4.—Sclerotia of silver scurf. (a) The surface view of an infected area, showing the sclerotia and their relation to the outer layer of cells. (b) An isolated sclerotium, much enlarged, in the early stages of germination. (After T. Johnson.)

DISTRIBUTION OF THE DISEASE.

Silver scurf has been known in Europe since 1871, when it was apparently first found and described by Hertz in Austria. In 1897-98 it was reported in Germany by Frank as causing a sort of dry rot. Johnson in 1903 reported it as causing considerable dry rot in Ireland and the following year it was reported in England by Smith and Rea. Up to the present writing silver scurf has been reported from only one locality in the United States. Clinton found it in Connecticut "on a few tubers among the many varieties to be tested

that year at the station." It should be noted that he believes the disease was introduced into Connecticut on imported varieties.

The disease was first found by the writer in the fall of 1912 in two barrels of potatoes shipped from western New York to Washington, D. C. No count was made, but it was estimated that at least 10 per cent of these potatoes was infected. Later it was found on Irish Cobblers bought in the local market early in December, 1912. These potatoes were raised in Maryland about 15 miles from Washington. Each tuber was examined and it was found that 56 per cent of this collection (2 bushels) was infected with silver scurf. More recently the disease has been found on potatoes from Virginia, Vermont, Maine, Kansas, West Virginia, New York, Florida, and Wisconsin, which tends to show that it may be quite generally distributed throughout the eastern half of the United States. This is especially interesting as showing its rate of spread, since it was first observed in this country in 1907 by Clinton and could hardly have existed long prior to this date without being observed by pathologists.

IS IT INJURIOUS?

It has been quite definitely established by earlier workers that *Spondylocladium* does not attack the foliage of the potato plant, but is confined chiefly to the potato tuber. Although the morphology of this fungus has been beautifully pictured and well described, very little is known regarding its effect on the tuber further than a few general statements occurring in the literature, none of which are based on experimental evidence. It is not probable that silver scurf is as destructive as our common *Oospora* scab, yet the following statements tend to show that some damage does occur from this disease.

According to Frank, silver scurf has the same effect on the potato as the *Fusaria*. This comparison is hardly justifiable in the light of our recent contributions on the various parasitic species of *Fusaria*, although it conveys some idea as to its destructiveness. Appel and Laubert are of the opinion that *Spondylocladium* has little destructive effect on the potato. It has already been pointed out that the fungus studied by Appel and Laubert may be different from the one common on the potato in America. Johnson, of Ireland, believes that "it is a true parasite, and apparently may do considerable unsuspected damage to the potato crop in Ireland. It may give rise to a skin disease or 'scab' of the potato tuber, and in a more advanced stage of attack to a 'potato rot'." Massee recommends that infected tubers should not be used for seed purposes. By Bohutinsky it has been stated that a species of *Helminthosporium* is the cause of leaf-roll. The fungus reported as causing leaf-roll has since been identified by

Appel as *Spondylocladium atrovirens*. This is also quite apparent from Bohutinsky's figures. It does not seem very probable that silver scurf is the cause of leaf-roll, but it may well be that it causes abnormal plants in certain instances. The fact that it disfigures the tuber and causes abnormal shrinkage is alone sufficient to involve considerable loss where tubers are to be used for human consumption after a considerable period of storage. It is not without destructive effect on the early varieties as well, and especially with red-skinned ones. A shipment has come to the writer's attention in which marked disfiguration occurred in the Bliss Triumph variety grown in the South for the early market. The tubers in some cases were so badly infected that the red color, so characteristic of the sound tuber, was no longer in evidence. In such cases considerable loss occurs, due to the sorting and to the decrease in market value of the infected tubers.

The big question in connection with silver scurf has to do with the effect it will have on the tubers used for seed purposes. What will be the effect on the yield and general vigor of the crop grown from seed infected with this disease? What effect will it have on germination, and will the wounds or lesions due to *Spondylocladium* increase the susceptibility of the parent tuber to the ravages of wound parasites? Likewise, the relation of the fungus to the soil and the method of spread of the disease in storage are open questions. These are problems that can not be answered at present, but which merit careful consideration, especially where the disease is very prevalent and the tubers are held in poor storage for a considerable length of time.

POSSIBLE METHODS OF CONTROL.

It is of special interest to know whether this disease, confined as it is chiefly to the periderm, can be controlled by the well-known formalin treatment used for the Oospora scab. It is claimed by Johnson that such is the case. He treated tubers for one hour in an 0.8 per cent formalin solution (about 2 pints to 30 gallons of water) and planted the same. Other diseased tubers not treated were planted as checks. When the potatoes were harvested in the fall it was found that the treated tubers were free from disease, while those from the checks were infected with the brown-mold stage of *Spondylocladium*, indicating that the 0.8 per cent formalin solution either killed or materially inhibited the growth of the fungus.

The effect of the formalin and corrosive-sublimate treatment as a means of destroying silver scurf has also been tested in the laboratory of Cotton and Truck Disease and Sugar-Plant Investigations. Two varieties of potatoes, the Irish Cobbler and the Green Mountain, were washed and soaked in formalin or corrosive sublimate. Follow-

ing this treatment the specimens were placed in moist chambers under conditions favorable for the fungus to fruit. In every case viable spores were produced from 2 to 12 days after treatment. The germinating capacity of the spores was determined by placing them in water for 24 hours. In every case the spores germinated.

As shown in Table I, neither corrosive sublimate nor formalin used twice as strong as in common practice for a period of five hours killed the fungus.

TABLE I.—*Effect of formalin and corrosive sublimate on silver scurf.*

Date.	Variety tested.	Number treated.	Fungicide used.			Result.	
			Name.	Strength.	Time of treatment.	Period in moist chamber.	Viable spores.
				<i>Per cent.</i>	<i>Hours.</i>	<i>Days.</i>	
Jan. 30.....	Irish Cobbler.....	50	Corrosive subli- mate.	0.2	2	7	Present.
		25	Formalin.....	.4	2	7	Do.
Feb. 10.....	Green Mountain...	10	do.....	.4	2	2	Do.
		10	Corrosive subli- mate.	.1	1½	2	Do.
Feb. 11.....	do.....	10	Formalin.....	.4	5	12	Do.
		10	Corrosive subli- mate.	.1	5	12	Do.
Feb. 12.....	Irish Cobbler.....	10	Formalin.....	.4	4	4	Do.
		10	Corrosive subli- mate.	.1	4	4	Do.
Feb. 14.....	do.....	10	Formalin.....	.4	3	2	Do.
		10	Corrosive subli- mate.	.1	1½	2	Do.
Mar. 20.....	Eureka.....	20	Formalin.....	.8	19	10	Do.
Mar. 21.....	do.....	20	do.....	.8	5	10	Do.

These data suggest that the ordinary formalin and corrosive-sublimate methods in vogue for controlling *Oospora* scab do not kill *Spondylocadium*. This is not surprising in view of the fact that the fungus produces numerous sclerotia and penetrates all parts of the periderm and in severe cases even extends into the parenchyma. Johnson used an 0.8 per cent solution of formalin and succeeded in preventing the reappearance of silver scurf. An 0.8 per cent solution of formalin is twice as strong as that commonly used in this country for *Oospora* scab. In the test on January 30, 1913, recorded in Table I, a double strength of corrosive sublimate (about 4 ounces to 15 gallons of water) killed the tubers, but the fungus developed viable spores after 7 days. On March 20, infected tubers were soaked 19 hours in an 0.8 per cent formalin solution and immediately placed in a moist chamber. The fungus produced viable spores after 10 days. It should also be noted that many of the eyes of the tubers were killed by this treatment. Neither does dry heat at 50° C. for 5 hours kill the fungus. This was learned in connection with numerous experiments planned to determine the effect of dry

heat on tubers infected with *Phytophthora infestans*. Spondylocadium fruited from 4 to 10 days after the tubers had been subjected to 50° C. for 2 to 10 hours. If the potatoes were kept at 50° C. for longer periods their germinating capacity was injured. This tends to show that the viability of the fungus is even greater than that of its host. Experiments are in progress to determine further the value of formalin as a means of controlling this disease.

RELATION TO THE SEED-POTATO INDUSTRY.

In order to gain some idea as to the amount of silver scurf present on potatoes being used for seed purposes this spring, several days were spent examining the seed stock being planted in the vicinity of Norfolk, Va. A shipment of over 500 barrels raised in northern Vermont came to the writer's attention. These potatoes were shipped to Norfolk last November and stored at a temperature ranging from 40° to 65° F., according to the statement of the owner. Some *Phytophthora* rot was in evidence in this stock. The combination of high temperature and moist condition, the latter due to the soft-rot, favored the development of Spondylocadium. Both the brown-mold and the sclerotial stages were readily detected, especially the former. Three barrels were sorted with the following results:

First barrel (by measure), infection with silver scurf..... 40 per cent.

Second barrel (by measure), infection with silver scurf.... 2 per cent.

Third barrel (by measure), infection with silver scurf..... 50 per cent.

It was impossible to examine every potato in any considerable number of barrels, so 17 other barrels from the collection of over 500 were dumped separately and the amount of silver scurf estimated. This was not especially difficult, because of the prevalence of the brown-mold stage, which is quite conspicuous when well developed. The amount of silver scurf ranged from about 1 to 90 per cent. When the amount of soft-rot was great the percentage of silver scurf was less, due, it is believed, to the excessive moisture present, a condition unfavorable for the rapid spread of the fungus. In 10 of the barrels examined the amount of silver scurf ranged from 25 to 90 per cent and in the remaining 10 it varied from about 1 to 25 per cent.

Another collection, consisting of 25 barrels of potatoes which had just arrived from Aroostook County, Me., showed about 25 per cent of silver scurf. It was strikingly noticeable in this collection that the disease was not as far advanced as in the earlier collection examined, and only the sclerotial stage was in evidence. Still another collection from Maine needs mention. It consisted of 15 barrels grown in the south-central part of the State. This collection was remarkably free from late-blight, but showed 35 per cent of silver

scurf. In three of the barrels that were sorted the following amount of *Spondylocadium* were found:

First barrel (by measure), infection with silver scurf.....	30 per cent.
Second barrel (by measure), infection with silver scurf....	40 per cent.
Third barrel (by measure), infection with silver scurf.....	35 per cent.

Three of the other barrels were emptied and the amount estimated. It was approximately the same as in the three barrels sorted. The infection in this collection had progressed farther than in the shipment examined from Aroostook County. This was possibly due to the different storage conditions to which the two lots of potatoes had been subjected. Small collections of other lots of seed potatoes from Maine on which silver scurf was also present were brought to the writer's attention, but the quantity examined was insufficient to make any just estimate as to the amount of this disease.

Although only comparatively few lots of seed have been examined, yet it is sufficient to show that silver scurf is a common disease on potatoes in Maine and Vermont, two States that furnish a considerable amount of seed to various sections of the United States, and since it is present on the seed going out from these two States it is possible that silver scurf is quite generally distributed in the eastern half of the United States.

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THE DASHEEN, A ROOT CROP FOR THE SOUTHERN STATES.¹

BY ROBERT A. YOUNG, *Scientific Assistant, Office of Foreign Seed and Plant Introduction.*

INTRODUCTION.

While Mr. O. W. Barrett was connected with the Porto Rico Agricultural Experiment Station previous to 1905, he brought together and grew a large collection of the tuberous-rooted aroids which are important food plants of the Tropics. He drew attention to the possibilities of these aroids in a bulletin published in 1905,² and when he entered the Office of Foreign Seed and Plant Introduction he assembled a still larger collection from different parts of the world. Several field trials of them were made at Gotha, Fla., and Gough, S. C. The results of these early experiments in the United States were published in 1910.³

As a result of these preliminary trials, in which, naturally, many of the introduced varieties failed, one of the forms, the dasheen, proved to be of unusual promise.

This paper deals with some of the more important features of the field experiments with the dasheen under the writer's direct supervision, as well as some greenhouse experiments in the production of blanched shoots, and with the results of many experiments in the cooking and preparation of the shoots and tubers for the table.

In 1909, from a small experimental plat grown near Charleston, S. C., it became apparent that the dasheens, which are closely allied to the taros of Hawaii, China, and Polynesia, were well adapted for culture in certain of the moist lands of the South. Since that time the endeavor has been to propagate a stock of the best varieties sufficient to make possible their distribution on a large scale. Certain varieties secured originally from the island of Trinidad and other parts of the West Indies were found to be satisfactory in yield and to be of higher quality than others in the collection. These are the varieties to which particular attention is now being given, though many others are under investigation.

¹ Issued May 17, 1913.

² Barrett, O. W. The yautias, or taniers, of Porto Rico. Porto Rico Agricultural Experiment Station, Bulletin 6, 27 p., 4 pl., 1905.

³ Barrett, O. W., and Cook, O. F. Promising root crops for the South. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 164, 43 p., 1910.

The origin of the word "dasheen" is somewhat obscure, but Mr. Barrett, who has spent some time in Trinidad, as well as in other parts of the West Indies, states that it originated in Trinidad and suggests an explanation which seems at least probable. Two possible derivations are given: "de la Chine" or "da Chine" (the latter pronounced dah-sheen, being the form in the patois of the French West Indies), meaning "from China"; also "des Indes" (pronounced daze-eend, or daze-and), meaning "from the Indies." Mr. Barrett believes the former to offer the more likely explanation.



FIG. 1.—A field of dasheens as it appears in September. These broad-leaved plants when full size stand 4 to 6 feet high and shade the ground completely. The seed tubers are planted in March; the harvest takes place in October. This planting is on hammock land at the United States Plant Introduction Field Station, near Brooksville, Fla.

The dasheen is also known in various parts of tropical America under the names "malanga," "eddo," "coco," "taya," and "tanier" (also spelled "tannia" and "tanyah"). These names are likewise often applied to the yautia and taro.

DESCRIPTION.

Dasheen plants are members of the botanical family Araceæ, to which belong also the calla, the Indian turnip, and the caladium, or elephant's-ear. The dasheen belongs to the genus *Colocasia*, but there has not as yet been sufficient botanical work done on this group

to make it possible to determine the species. The leaves of the dasheen are shield shaped (figs. 1 and 2), like the caladium and the taniel of the South, and contain the same acrid principle that characterizes the Indian turnip and most other plants of this family. They should never be tasted raw. The tubers of the most promising Trinidad



FIG. 2.—A hill of the Trinidad dasheen. One dasheen plant will cover a square yard of ground and produce 4 to 10 pounds of tubers on good rich soil. This variety is one of the best flavored yet introduced.

varieties are free from this acidity even in the raw state, but because of the possibility of tubers of an acrid variety being mixed with these it is best never to taste them uncooked. In cases of the accidental tasting of acrid tubers or leaves, lemon juice in a little water is found to alleviate the ill effects.

If dasheens are handled in water in scraping or paring them for cooking, a level teaspoonful of sal soda should be added to each quart of water. The outer part of the tubers contains an irritant that causes the hands to sting in somewhat the same way as the mouth and throat from the eating of raw, acrid leaves or tubers. The hands are affected in this way even in the case of tubers that are not acrid to the taste. If water is not used while scraping them, it is best to wash the hands afterwards in soda water of the strength mentioned.

The dasheen corms and tubers¹ are similar to the potato in composition, but they contain less water, and in consequence the content of starch, as well as of protein, is roughly a half higher than in the potato.² In addition they possess a very agreeable, nutty flavor. Remarkable digestibility has long been attributed to the aroid tubers, and in Hawaii, as well as in other countries where they are grown, their use for invalids is often prescribed. The starch grains of the taro and dasheen are among the smallest known in all food plants, and this is thought by some to account in part for the ease of digestion.

RESULTS OBTAINED IN CULTIVATION.

Experiments on a small scale in growing the dasheen have been made at a number of points in the Northern States, even as far north as New York, but while tubers were usually produced they were comparatively small. The reports received do not at present warrant the Department of Agriculture in recommending dasheens for cultivation, even in vegetable gardens, north of the Carolinas. Future experiments, however, may show that this limit can be extended.

The first marked success in the experimental growing of dasheens in this country was in 1909 in South Carolina, to which reference has already been made. Forty bushels were harvested from one-tenth of an acre. The next year the propagation of the dasheen was begun at the Plant Introduction Field Station, Brooksville, Fla., but it was not until the season of 1912 that a crop large enough for a wide distribution was raised. Seven acres were grown that season, though more than 2 acres of this were on what proved to be very unsuitable land. The clay subsoil came almost to the surface in many places and in others formed "pockets" which held the excessive rainfall, to the detriment of the plants.

¹ Each hill of dasheens contains one or two rather large, somewhat spherical corms, around which develop numerous cormels. The latter are popularly called "tubers." For the corm, however, because of the differences in size and form between it and the cormels, it is found convenient to retain the technical name in common usage.

² An average of 11 analyses of dasheens by the United States Department of Agriculture gives 27½ per cent of carbohydrates (starches and sugars) and 3 per cent of protein. For the white potato the generally accepted figures are 18 per cent of carbohydrates and 2.2 per cent of protein. The sweet potato approximates the dasheen in carbohydrates, but it is even lower than the white potato in protein.

A total yield of about 1,200 bushels was obtained. Of this quantity approximately one-third consisted of marketable tubers (fig. 3), one-fifth of corms, one or two of which occur in each hill, and the remainder, nearly one-half, of small tubers, which have been distributed for planting. About one-half of these small tubers would be large enough for the home table, but are too small for the market. These may be used for stock food, either raw or cooked, in connection with other food. No careful experiments have as yet been made, however, in this country¹ upon which to base definite statements relative to the use of dasheens for stock food.

The corms, which sometimes reach a weight of nearly 5 pounds each, are usually of a quality fully equal to the tubers and are excellent when baked, though occasionally one is found that, even when thoroughly cooked, proves a little too firm to be palatable. It is believed, however, that this undesirable character can be eliminated by using for planting tubers from only such plants as produce corms of satisfactory quality.

The corms may be converted into flour, which can be made into soups and gruels. Dasheen flour when used with wheat or rye flour makes most delicious pancakes, biscuits, and bread. The pancakes do not become heavy by standing. Some 3,000 pounds of flour were produced during the season of 1912-13 from 200 bushels of corms and tubers and this flour is now being used experimentally in cooking and baking.

Dasheen corms may also be forced with bottom heat in a greenhouse, and the blanched shoots, by special cooking to remove the acidity, may be used like asparagus. The shoots are very tender and have a delicate flavor, suggestive of mushrooms. There are probably few plants so well suited for forcing purposes as the dasheen. Experiments carried on at the greenhouses of the Department of Agriculture at Washington in 1912 and in those of the Battle Creek Sanitarium at Battle Creek, Mich., early in 1913, indicate that five to eight crops of these delicate shoots can be harvested. The first cutting can be made in 35 to 40 days after the corms are set in the sandy soil of the greenhouse bench, and subsequent ones at intervals of 10 to 14 days.

The tops of corms not utilized in any of the ways mentioned may be used the succeeding season for planting, and the basal part—a half or more—may be used for the table or for stock food.

While all of the tuberous growth of the dasheen is edible, the medium-sized or large tubers are especially adapted for use like potatoes. At present it seems probable that these will constitute the principal value of the crop, as these tubers when properly selected will

¹ See U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 164, entitled "Promising root crops for the South," p. 16, 1910.

doubtless command a much higher price than either the corms or the smaller tubers. The corms do not usually keep as well as the tubers and it is therefore advisable to utilize them as early as practicable after harvesting.

CULTURAL REQUIREMENTS.

The dasheen requires rich, sandy soil, very moist but well drained. The plant will not be greatly injured by occasional flooding for a short period. Such lands as the so-called hammock lands of Florida are especially adapted for the cultivation of this crop. Any low-lying sandy land that is fairly well drained, but still too wet for general field crops, can be used to advantage. On these low lands it would be advisable to plant on ridges.

Planting should be done as early in spring as the conditions of soil and climate will permit. This may be as early as the first of February in southern Florida and as late as the last of March or the early part of April in the Carolinas.

Preliminary experiments indicate that it does not pay to use very small dasheens for planting if larger tubers are available, as this may result in the yield being reduced by as much as 15 per cent. Tubers of 3 to 5 ounces in weight are preferable for planting. For field culture the tubers, unless very small or very large, are planted, singly and entire, from 2 to 3 inches deep in hills 3 feet apart, the distance between rows being 4 feet. This will permit horse cultivation. In cultivating during the summer the soil should be gradually drawn to the plants and the plants kept free from weeds; they usually require little cultivation after becoming large enough to shade the ground. Well-grown plants will reach a height of $4\frac{1}{2}$ to 6 feet or more by midsummer.

The crop matures in about seven months, although the tubers can be utilized for home use in six months or less from planting. The harvesting of the main crop may be deferred a month or two, if desired, but if it is to be done at one time, in order to have warm, dry weather for the dasheens to dry properly on the ground, it should not be delayed till there is danger of frost. For this reason it will usually be best to harvest dasheens sometime in October. It will sometimes prove advantageous in practically frost-free localities or where the roots can be protected to leave them in the ground until wanted for use or until spring.

Where soil and climatic conditions are favorable, dasheens will produce from 4 to 10 pounds or more to the plant. Under experimental conditions at Brooksville, Fla., in different soils and in different seasons, the Department of Agriculture has secured yields ranging from 140 to 450 bushels to the acre. Satisfactory results have not

been obtained, even in good soil, when two successive crops of dasheens are grown on the same ground.

The growing of a dasheen crop is probably no more expensive than that of a potato crop. Although the season for the dasheen is much longer than that for the potato, the large leaves of the former tend by shading to keep down weeds after midseason.

FERTILIZER.

Experiments made at the Porto Rico Agricultural Experiment Station¹ indicate that ordinary stable manure is better suited than commercial fertilizer for use in growing dasheens and other plants of this kind. Where there is a deficiency of potash in the soil, however, as in most of the sandy soils of the South, and especially where stable manure is not available, a fertilizer rich in potash should be applied. From 600 to 1,000 pounds to the acre may be used, the quantity depending upon the state of fertility of the soil. The fertilizer should be applied within a few weeks after planting, and a second application may be desirable in midsummer in some instances.

HARVESTING.

Harvesting, for the present at least, is more costly than for potatoes, because of the hand labor required in separating, cleaning, and sorting the tubers. A 10-inch plow has proved satisfactory for turning the plants over when the area grown is large enough to justify its use. Even on sandy land, however, the multitude of fibrous roots hold the soil so firmly that a clump of tubers can not be separated except by hand. The plants should be grasped by the tops and the clumps thoroughly shaken to dislodge as much of the soil as possible. They can then be broken apart by means of the tops, and in dry weather the tubers, with tops still attached, should be left on the ground to dry for four to six days.

It is highly desirable to harvest the crop during a dry spell, as it is of the utmost importance that the tubers have time to dry well in the open air before being stored. The tubers should not in any case be exposed to frost.

GRADING.

The grading of dasheens is of primary importance, especially where the grower wishes to build up a market among hotels and other discriminating consumers. The first grade should contain only perfect tubers of uniform size and shape, weighing approximately 4 to 5

¹ See U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 164, entitled "Promising root crops for the South," p. 12, 1910.

ounces each (fig. 3). Some mechanical means of grading can no doubt be devised that will materially lessen the cost of handling. A very simple scheme where the quantity of dasheens is not too large is to



FIG. 3.—Dasheens for table use. These tubers contain 50 per cent more protein and starch than the potato, have a decidedly nutty flavor, and are very easily digested. They are formed in a compact cluster with smaller tubers, attached to and around a large central corm. Flour can be made of both corms and tubers, and the corms can also be forced for the production of blanched shoots for winter use. (Two-thirds natural size.)

make a wooden frame, say, 18 by 24 inches and 6 inches deep, with a bottom of parallel rounded slats or wooden rods at suitable distances apart. Rods of the diameter of a rake handle or slightly less will probably be found most satisfactory.

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For separating tubers too small for market the distance between the rods should be about $1\frac{3}{4}$ inches. A frame of the size mentioned can be readily handled by one man. If, however, the quantity of dasheens is large it will be desirable to have a stationary grader of larger dimensions. It should be placed on an incline, so that the larger tubers will roll off at the lower end. If more than two grades of tubers are desired, an additional set of rods or bars at either greater or less distances apart can be placed a few inches above or below, as may be necessary. In the use of any grading device and in the handling of dasheens generally, care should be taken, as in handling potatoes, not to bruise them.

On account of the variability in the form of dasheen tubers some handwork will probably always be necessary where careful grading is required, but the amount of this can be greatly reduced by adopting some plan such as one of those outlined.

STORAGE.

The question of the best method of storing dasheens to prevent them from decaying is still under investigation. At present they appear to be no more difficult to keep in storage than sweet potatoes. They will usually keep well if stored in a dry place at a temperature of about 60° F. where the air can circulate freely among them. It is believed that they will also keep if placed in dry sand or earth in a dry cellar having a temperature of 60° F. or a little less.

CONCLUSION.

From the interest that has already developed among southern farmers who have become even slightly acquainted with the dasheen, it seems probable that this crop is destined to become of great importance to that section of the country. It can be grown as a summer crop in a region where the potato must be grown almost entirely as a spring crop, for it ripens its tubers in October and furnishes them for the table at a season when northern-grown potatoes have to be shipped in at prices relatively high, except in seaports. It is a good yielder, comparing favorably with the potato. If grown on well-drained land it is not injured as the potato is by unusually wet weather and is therefore suited for cultivation on lands where the potato would be a failure. Its culture on wet lands in the South where the water supply can be controlled by drainage or otherwise is a subject of further investigation.

The young tops when properly cooked can be substituted for spinach at a time when the weather is too hot to grow spinach. The blanched shoots obtained by forcing dasheen corms in the dark in a greenhouse or under other suitable conditions constitute an entirely

new product, which is meeting with general approval. The nutty flavor of the tubers gives them a peculiar palatability which has struck the fancy of a large number of persons. The higher nitrogenous and starchy character gives them an advantage as food that would seem to make the plant, when compared with the potato, an even more valuable food producer.

RECIPES FOR THE PREPARATION OF THE DASHEEN.

This vegetable is a staple article of food for millions of people in tropical and subtropical countries. In general it is used in the different ways in which the white potato is used. It may also be candied like the sweet potato. The flesh of the corms and large tubers is frequently somewhat gray or violet when cooked, but this does not affect the flavor.

When uncooked dasheens are being scraped or pared they should be handled in water to which a teaspoonful of sal soda to the quart has been added, in order to prevent irritation to the hands.

BAKED DASHEENS.

Dasheens, large or small, may be baked like potatoes, in a quick oven. They should first be washed and scrubbed to remove the fibrous part of the skin. When practicable to do so it is often desirable to scrape the dasheens before baking, as they are then more convenient for eating and the soft crust which forms when they are properly baked is particularly delicious. The corms may be cut in half from top to base in order to lessen the time needed for baking. The time required is about the same as for potatoes of the same size. They should be served hot. Season with salt and plenty of butter, and pepper if desired. Gravy instead of butter may be used.

The dasheen when properly baked and served is mealy and the flavor is much like that of the white potato, but more or less suggestive of chestnuts. If not overbaked, the skin when properly scrubbed or scraped beforehand will be found of delicious flavor. As the dasheen is drier than the potato it requires more butter.

STUFFED DASHEENS.

Proceed the same as in baking, and when the dasheens are done follow the method used for stuffed potatoes, using more butter, however. If cream instead of milk is used for moistening, still better results are secured.

The corms are especially adapted for serving in this manner, but they should always be scraped and, unless quite small, may be cut in half. Instead of mashing dasheens it will always be found better to rice them with a potato ricer or to rub them through a coarse sieve.

SCALLOPED DASHEENS.

Pare raw dasheens and slice thin, putting in layers in a well-buttered baking dish, seasoning each layer with salt and butter and sprinkling each lightly with flour. Nearly cover with rich milk and bake.

This method of serving the dasheen will be found particularly well adapted for banquets or formal dinners, but in such cases individual baking dishes or casseroles should be used.

The above recipe may be varied by using less butter and adding grated cheese. Pepper may also be used in seasoning if desired. Cold boiled instead of raw dasheens may also be utilized in these recipes.

BOILED DASHEENS.

Large dasheens are preferable for boiling, though small ones may also be used. They should be boiled in the skin and may be served thus, or the skins may be removed before serving. Dasheens should not be boiled longer than potatoes of the same size, and they should never be pared before boiling.

MASHED DASHEENS.

On account of the somewhat mucilaginous character of dasheens they are not recommended for mashing in the ordinary way. They do, however, make an excellent dish when boiled in the skin, peeled, and riced, or put through a sieve, as previously mentioned. Rich milk or cream and a liberal quantity of butter should be used in seasoning when particularly good results are desired. It should be remembered that riced or mashed dasheens may be a little dark, especially when corms or large tubers have been used.

CREAMED DASHEENS.

Boil the dasheens in the skin and proceed as for creamed potatoes.

DASHEENS AS FILLING FOR FOWL AND OTHER MEATS.

2 parts of riced dasheen.

1 part of bread.

1 egg.

Butter, according to quantity of above.

Season to taste with salt, pepper, sage, and onion.

The dasheens should be boiled and riced in the usual way.

DASHEEN SOUP.

3 cups of boiling water.

3 cups of milk.

3 cups of riced dasheen.

3 tablespoonfuls of butter.

Salt and celery salt to taste.

Parsley or grated onion if desired.

Boil and rice the dasheens as described. Into a double boiler put the boiling water and add the milk and dasheen. Bring to a boil and cook for 5 to 10 minutes. Season and serve.

CANDIED DASHEENS.

Peel parboiled dasheens and cut into thick slices or strips; prepare a sirup made in the following proportions:

1 cup of sugar.

2 cups of hot water.

2 to 3 tablespoonfuls of butter.

Salt if desired.

Either granulated or brown sugar may be used. Cinnamon may be added if desired. Boil in this sirup in a covered dish until soft, and brown in the oven.

DASHEEN PIE.

Any recipe for sweet-potato pie will probably do, but the following is suggested as being economical and otherwise satisfactory. The dasheens should be boiled and riced as usual.

2 cups of riced dasheen.
 $\frac{1}{4}$ cup of butter.
 $\frac{3}{4}$ cup of white sugar.
 $\frac{1}{2}$ teaspoonful of cinnamon.

$\frac{1}{2}$ teaspoonful of nutmeg.
 1 egg (white and yolk beaten separately).
 2 cups of milk.
 $\frac{1}{2}$ lemon, juice and rind.

Bake in a deep pie tin. Serve warm.

DASHEEN PUDDING.

Proceed the same as with the above recipe for pie. Bake without crust in a deep dish well buttered.

DASHEEN SHOOTS.

1. Cut the blanched shoots into 2-inch lengths, pour on an abundance of boiling water, add salt, and boil for 12 minutes; drain, pour on enough cold ¹ milk so that the shoots will be completely covered when it boils, season with salt, and boil for 5 minutes; drain, season with butter, and serve on toast or plain. Cream sauce may be used in serving, if desired.

2. Instead of boiling in milk after draining off the first water, add a little piece of bacon or other fat meat ² and then cover the shoots with cold water, season with salt, and boil for 5 minutes. Drain and serve.

DASHEEN GREENS.

The young leaves of dasheens and other plants of this class are used for greens, like spinach, in all countries where these crops are grown. The leaves are seemingly in more suitable conditions for greens in the first half of the season than later, and it will probably be found best to restrict their use to the earlier period. They should never be tasted raw.

Remove half or more of the midrib of the leaf and boil for 12 to 15 minutes in water to which a good pinch of baking soda has been added. Drain off the soda water, wash with clear boiling water, and then boil in water seasoned with salt for 20 to 30 minutes, or until tender. Other seasoning may be added as desired.

The above treatment destroys the acidity, but boiling in soda water has been found unnecessary when the greens are cooked with fat meat.

¹ The purpose in using cold milk or water after the first boiling is to prevent the shoots from becoming too soft.

² The fat of the milk or meat seems to assist in destroying the acidity.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 128

WILLIAM A. TAYLOR, Chief of Bureau.

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MISCELLANEOUS PAPERS.

Some Profitable and Unprofitable Farms in New Hampshire	{ FRED E. ROBERTSON and LAWRENCE G. DODGE
The Strength of Textile Plant Fibers	{ LYSTER H. DEWEY and MARIE GOODLOE

Issued May 24, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1913.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, WILLIAM A. TAYLOR.

Assistant Chief of Bureau, L. C. CORBETT.

Editor, J. E. ROCKWELL.

Chief Clerk, JAMES E. JONES.

[Cir. 128]

SOME PROFITABLE AND UNPROFITABLE FARMS IN NEW HAMPSHIRE.¹

By FRED E. ROBERTSON, *Scientific Assistant*, and LAWRENCE G. DODGE, *Agriculturist*,
Office of Farm Management.

INTRODUCTION.

A detailed study of the financial results of farming was made in two typical dairying sections of New Hampshire. Of these localities one was in the Suncook Valley, comprising the greater portion of six towns,² Barnstead in Belknap County, and Pittsfield, Chichester, Epsom, Pembroke, and part of Loudon, in Merrimack County, and the other along the Connecticut River, in Grafton County, including Haverhill, Piermont, and part of Bath.

Each real farm in those areas was visited by a representative of the United States Department of Agriculture and the New Hampshire College Agricultural Experiment Station. Statements of the total investment, the receipts, expenditures, and other details of the year's business were obtained from the farmers. These statements were from the farmers' own careful estimates or, wherever possible, their actual records.

Similar investigations were made in four towns in southern New Hampshire in 1909.³ In the region then covered there was little of the typical dairy farming of New England. The present areas were selected to show something of the financial results of dairying under average conditions, both in the production of market milk and of cream for the creameries. The region in the Suncook Valley is primarily a market-milk region, while that in Grafton County, though some milk is shipped, is more especially a creamery region.

In the two regions 428 farms in all were recorded and the financial results tabulated. In the study of these farms there appeared a wide variation in profitableness among them. To bring out the relation

¹ Issued May 24, 1913.

The survey in which the material for this circular was obtained was made cooperatively by the New Hampshire College Agricultural Experiment Station and the Bureau of Plant Industry, U. S. Department of Agriculture.

² The term "town" as here used is synonymous with the word "township" as used in most parts of the country.

³ The results of these investigations have been published by the U. S. Department of Agriculture in Circular 75 of the Bureau of Plant Industry.

between some of the methods of management of the farms and the profits the most profitable 100 farms were compared with the least profitable 100.

EXPLANATION OF TERMS USED.

To make the discussion more brief and clear, a few of the terms used will be defined here:

Capital.—The term "capital" as used here relates to the value of the farm and all the equipment; it includes the value of the real estate, the machinery, tools, live stock, hay, grain, seed, etc., plus the amount of cash ordinarily kept on hand. The average of the amounts of capital at the beginning and at the end of the year, April 1, 1910, and March 31, 1911, is considered the average capital invested in the farm business for the year.

Receipts.—"Receipts" include all the money received from the sale of any product of the farm, including live stock, or for any labor of man or team performed off the farm, or for rent or the like. If the amount of capital at the end of the year is greater than at the beginning of the year, either as a whole or in some one class, such as live stock, this difference would be included in the receipts. When referred to separately it will be called "increased inventory."

Expenses.—"Expenses" include all outlay for the farm, such as cash paid for labor, feed, taxes, etc., but do not include any household or personal expenses of the farmer or his family. Any decrease in the amount of capital during the year, or "decreased inventory," is treated as an expense.

Unpaid family labor.—"Unpaid family labor" is properly an item of expense. It is the value of the labor of the other members of the farmer's family while assisting in the farm work (not in household work). It will be treated here separately from other items of expense.

Farm income.—"Farm income" is the difference between the total receipts and the total cash expenses. The farm income includes the value of the combined efforts of the farmer, of those of his family who help him, and of the use of the capital which he has invested in the farm business.

Labor income.—"Labor income," or the "farmer's labor income," represents what the farmer has earned by his own labor and supervision. It is found by subtracting from the farm income the value of the unpaid family labor and also 5 per cent interest on the capital invested.

No account has been taken of the perquisites the farm furnishes to the farmer, such as a house to live in, firewood, milk, and vegetables. The farmer's labor income can, however, be easily compared to the cash wages of a farm hand of the better class, who is furnished a house, firewood, the opportunity to make a garden, etc.

PROFITABLE AND UNPROFITABLE FARMS COMPARED.

The averages of the group of 100 profitable farms (called in the tables "better farms") are strikingly different in many respects from those of the other group (called the "poorer farms"). Certain factors will be found in the following tables to differ as widely as the difference in profits (labor income), while in other respects the average for the farms of one group does not differ appreciably from that of the other group. Care was taken to eliminate from this comparison those farms which made large profits or losses because of

some unusual condition, such as the sale of a large quantity of lumber or a loss due to an unusual crop failure.

TABLE I.—*Comparative area of 200 selected farms and of all the 428 farms in New Hampshire of which data were obtained.*

Area.	100 better farms.	100 poorer farms.	Average, 428 farms.
	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>
Tillable.....	50	44	43.2
Pasture.....	130	109	99.8
Woodland.....	23	29	30.5
Total.....	203	182	173.5

The difference in acreage is slight, as shown in Table I. The group of better farms has an average of only 21 acres more land per farm than the poorer group and only 6 acres more of tillable land. When it is considered that the labor income of the farmers on the better farms averages \$830 and that those farmers on the poorer farms have a minus labor income averaging \$341 (meaning that they are \$341 short of beginning to earn any pay for their own time), the small difference in acreage does not seem to offer an adequate explanation for the great difference in income.

One more point is to be considered: When these same 200 farms are redivided on the basis of tillable acreage, the 100 having the largest tillable acreage have an average labor income of \$311, while the 100 with the smallest tillable acreage have an average of \$190. This would indicate that acreage is certainly one factor that counts in determining the labor income, although the small difference in acreage between the 100 better and the 100 poorer farms suggests that it is not so important a factor as it has proved in other regions where a similar study has been made.

TABLE II.—*Comparative distribution of capital on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Machinery and tools.....	\$453	\$351	\$352
Real estate.....	4,864	5,332	4,404
Live stock.....	1,592	1,045	1,152
Grain and feed.....	145	106	106
Cash to run business.....	163	144	137
Total.....	7,217	6,978	6,151

The poorer farms are here shown to have a little less total capital than the better farms, a difference of \$2.39 per farm, but this is so small as to offer no reason for any great difference of earning power between the two groups.

A marked difference exists between the two groups in the distribution of capital, however. The better farms have a much smaller part of their total capital in the form of real estate and a proportionately larger part in working capital of various kinds, including live stock, machinery and tools, grain and feed, and cash to run the business. With their total capital nearly equal, the better farms have 42 per cent more working capital than the poorer farms. Expressed in another way, the better farms have 32.6 per cent of their total capital as working capital and the poorer have only 23.5 per cent



FIG. 1.—Buildings on a farm in the Suncook Valley, N. H. These represent too large an investment in buildings for the average farm of the region in which data were obtained.

in working capital. The latter illustrates quite well the old expression "land poor." This condition is often varied by having relatively too much money involved in another form of real estate, namely, buildings. Figure 1 illustrates the size and quality of buildings which are out of proportion to the income from the average farm of these two regions. With a slightly less acreage and a little less total capital the poorer farms still have a larger valuation of real estate. Too expensive buildings are a factor contributing largely to this condition.

TABLE III.—*Comparative distribution of receipts on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Crop sales.....	\$347	\$136	\$262
Net live-stock sales.....	260	121	162
Sale of stock products.....	1,389	612	814
Increased inventory.....	184	30	110
Outside labor.....	138	32	91
Total receipts.....	2,318	931	1,439

The receipts from the better farms exceed those of the poorer by 149 per cent. The receipts from sales of stock and of stock products were each more than twice as great on the better farms as on the poorer. The crop sales on the better farms amounted to more than two-and-a-half times as much as on the poorer farms. The inventory of the better farmers increased \$184 a year; that of the poorer only \$30 a year. The better farms would seem from that not only to be selling off more products of all kinds, but to be at the same time improving the total value of the business. This improvement may be in the raising of more young stock, or in the building up of the real estate, or the adding to the equipment of tools and the like. The final item of receipts, namely, that from labor performed off the farm, is seen to be over four times as great on the better farms as on the poorer. This fact suggests that the farmers on the better farms were more careful to keep the men and teams busy at outside work during such times as they were not fully occupied with their farm work. On the other hand, this item might be the result of a condition wherein those better farmers were merely more fortunate in having outside work presented to them.

TABLE IV.—*Comparative distribution of expenses on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.	Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Hire of labor.....	\$259	\$181	\$173	Silo filling.....	\$11	\$6	\$8
Board of labor.....	76	74	59	Horseshoeing.....	24	20	20
Seeds.....	21	14	15	Milk hauling.....	11	11	8
Fertilizers.....	64	37	40	Taxes.....	73	78	66
Hay.....	17	11	15	All other expenses.....	38	40	40
Feed and grains.....	398	258	284	Total.....	1,083	792	796
Machinery.....	45	22	28				
Buildings and repairs.....	46	40	40				

The average expenses per farm on the better farms were \$291 or 36.7 per cent greater than on the poorer farms. This should be compared with the difference between the two groups in receipts,

in which respect the better group exceeded the poorer by \$1,387, or 149 per cent per farm. Greater profits do not therefore come from reduced expenses, but from an increased outlay and a much greater increase in receipts.

The better farmers spent over one-third more for hired labor than the poorer, and at the same time only \$2 more for the board of laborers. This suggests that the better farmers employed higher priced help though no greater numbers, or employed more by the day or otherwise without providing board. In short, the better group of farms used more labor without a corresponding increase in the amount of board furnished them in the farmers' households. The better farms expended 50 per cent more for seed and nearly twice as much for fertilizers as the poorer. In the largest item of expense—feed and grain—the better farmers exceeded the other group by over 54 per cent. The better farmers spent slightly more than twice as much on machinery as the poorer, but very little more on buildings and repairs. That is, the better farmers put money into production, but the expense for upkeep was noticeably much alike in the two groups.

The better farmers purchased more hay, though the total hay purchased by either group is trifling. The better farmers expended nearly twice as much in silo filling and one-fifth more for horse-shoeing. The latter was perhaps necessitated by so much more work away from the farm, which was shown in the distribution of receipts.

The milk-hauling cost is the same in both groups, though the quantity of milk sold is much greater on the better farms. It costs just as much to send 50 quarts of milk per day to the railroad station as to send 125 quarts per day.

The taxes are 6.4 per cent less on the better farms. This tax item again has some relation to the distribution of capital, for the better farms had a smaller investment in real estate, of which the whole is taxable, and a greater one in movable property, of which only part is taxed.

TABLE V.—*Comparative number and value of the live stock on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Average number of cows.....	16	10	12
Average value per cow.....	\$47	\$45	\$47
Sales of dairy products.....	\$1,290	\$359	\$746
Sales of dairy products per cow.....	\$80.62	\$35.90	\$62.16
Average number of horses.....	3	3	2.7
Average value of horses.....	\$148	\$134	\$133
Average total of animal units.....	27	18	19.2

The better farms supported 60 per cent more cows than the poorer and while their value per head was reckoned as only \$2 more on the better farms the sales of dairy products amounted to almost \$25 more per cow. This suggests that sufficient records of the production of cows are not kept to establish their real values. Better care and feeding may be responsible for much of the difference in production, but it is also likely that most cows are not valued according to their natural producing capacity.

The better farmers kept the same average number of horses as the poorer, but their value was \$14 a head greater on the better farms. This difference in value is not in proportion to the difference in earnings from outside labor, as the latter appears in the distribution of receipts.

The better farms have 50 per cent more animal units than the poorer group, corresponding to the greater investment in live stock as well as other movable property.

TABLE VI.—*Comparison of miscellaneous factors on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Age of farmer.....years.	48	56	51
Interest on investment.....	\$360	\$348	\$308
Family labor.....	\$53	\$130	\$70
Labor income.....	\$830	\$341	\$266

The farmers operating the better 100 farms were on the average 8 years younger than those on the poorer 100 farms. The better farms had a larger interest charge by \$12 than the poorer, corresponding to the small difference in investment. The better farms had the help of the family in farm labor to a value of less than 40 per cent of that on the poorer farms, a difference of \$77. It will be remembered that the better farms had a cash outlay for hired labor of \$78 more than that of the poorer. The total labor value, aside from the farmer's own time, was on the poorer farms almost the same as on the better. The greater proportion supplied by the family on the poorer farms does not seem to have been used so efficiently as the greater proportion of hired labor on the better farms. On the poorer farms the whole family evidently worked harder than on the better and to no purpose, for it will be remembered that the labor income of the better farms was \$830 against a minus labor income of \$341 on the poorer.

COMPARISON OF THREE AVERAGE FARMS.

Three farms have been selected from those surveyed, and the results are given here to show the character of the individual farms. Two of these farms, Nos. 1 and 2, are successful, and the other, No. 3, shows a minus labor income.

FARM NO. 1.

TABLE VII.—*Statement of the business of farm No. 1.*

[Area, 195 acres; 43 tillable.]

CROP RECORD.

Crop.	Acreage.	Unit of yield.	Yield per acre.
Silage corn.....	7	Tons.....	14
Hay.....	21	do.....	3.4
Clover hay (2 crops).....	6	do.....	5
Oats.....	7	Bushels.....	65
Potatoes.....	2	do.....	173

FINANCIAL STATEMENT.

Item.	Amount.	Total.
Capital.....		\$9,767
Real estate.....	\$7,000	
Machinery and tools.....	500	
3 horses.....	216	
20 cows ¹	950	
20 hogs.....	200	
40 chickens.....	20	
Other live stock.....	345	
Miscellaneous.....	536	
Receipts.....		3,688
Potatoes.....	195	
Live stock (net).....	625	
Hogs.....	385	
Creamery milk.....	2,433	
Eggs.....	50	
Expenses.....		2,327
Labor and board.....	780	
Seeds.....	18	
Grain for feed.....	1,000	
Fertilizers.....	100	
Machinery.....	225	
All other expenses.....	204	
Farm income.....		1,361
Less interest at 5 per cent on capital.....		488
Labor income.....		873

¹ Receipts per cow (milk), \$121; value per cow (grade Jersey breed), \$47.

The statement of the business for a year on farm No. 1 is taken from a farm in the Haverhill district which reported high yields of crops and animal products. It is a good example of a dairy farm, having a cropping system much better than the average, but still having rather a larger proportion of hay to other crops in respect to acreage. The production per cow was 7,586 pounds of milk for the year, a high average, indicating good cows, well cared for.

Two men and three horses have been employed on this farm during the year. What they produced to sell was almost wholly live stock or live-stock products, the only exception being less than \$200 worth of potatoes. The expense for labor is considerable, and part of this was required for the cows, since they were evidently well cared for. Twenty hogs and a number of pigs also required labor,

and these must also have consumed much of the purchased grain which formed a large item among the expenses. Both the total acreage and that tillable are about the average of the better 100 farms surveyed. The investment is larger than the average of the 100 farms and the labor income is also larger. It would seem that the labor used on this farm in connection with the live stock could at the same time have grown more crops to sell. Even with the available tillable acreage this labor might have raised more cash crops by making some slight changes in the rotation. For instance, a larger acreage of potatoes could have been cared for. The owner of farm No. 1 is not keeping more labor, because he is an older man. He is more than 20 years older than the owner of farm No. 2.

FARM NO. 2.

TABLE VIII.—*Statement of the business of farm No. 2.*

[Area, 200 acres; 50 tillable.]

CROP RECORD.

Crop.	Acreage.	Unit of yield.	Yield per acre.
Corn.....	2	Bushels...	50
Potatoes.....	3	do.....	200
Silage corn.....	6	Tons.....	15
Oats and peas.....	5	do.....	2.4
Hay.....	26	do.....	2
Clover.....	5	do.....	3.4

FINANCIAL STATEMENT.

Item.	Amount.	Total.
Capital.....		\$8.117
Real estate.....	\$5.150	
Machinery and tools.....	550	
16 cows.....	1,200	
3 horses.....	450	
4 hogs.....	65	
100 chickens.....	100	
Other live stock.....	272	
Miscellaneous.....	330	
Receipts.....		3.025
Potatoes.....	322	
Apples.....	95	
Wood.....	50	
Market milk.....	1,553	
Eggs.....	160	
Live stock (net).....	190	
Increase in inventory.....	655	
Expenses.....		1.250
Labor.....	50	
Seeds.....	30	
Grain for feed.....	450	
Fertilizer.....	200	
Machinery.....	50	
All other expenses.....	470	
Farm income.....		1.775
Less interest at 5 per cent.....		406
Labor income.....		1.369

¹ Receipts per cow (milk), \$91; value per cow (grade Holstein breed), \$75.

The statement of farm No. 2 illustrates a successful market-milk farm in the Suncook Valley. The crop yields are above the average, as are the receipts per cow from milk sales. The cash receipts from other sources than live stock were over \$450, and this farmer's total inventory had also increased \$655 during the year, adding that amount to the real income of the farm. Of that increase only \$115 was in the form of live stock, the remainder being in improved land and buildings, more machinery and tools, and more feed on hand.

This farm is very closely representative of the average of the better 100 farms in total and tillable acreage, but has about \$900 more total investment and a much larger labor income than that 100. A shorter rotation would evidently have given larger yields of hay and forage crops and so would allow somewhat more of the acreage to be used for crops to sell.

It will be well to compare these two farms. Farm No. 1 has a larger investment than farm No. 2 by \$1,650, but a smaller labor income by almost \$500. Farm No. 1 has \$663 more receipts, but \$1,077 more cash expenses. The greater receipts of farm No. 1 are primarily from sales of hogs and milk, the milk going to the creamery. The greater expenses are primarily in the items of hired labor and of purchased feeds. These extra feeds were used in part by more cows and still further by the large number of hogs. Evidently the sale of hogs did not pay a very wide margin above the cost of the grain purchased for them. The cows on farm No. 1 produced more value in milk per head than those on farm No. 2, but were not themselves valued so highly by their owner. This is very probably due to the fact that Jerseys (kept on farm No. 1) are not in such demand to ship out of the State as are Holsteins (kept on farm No. 2).

The difference in labor between these two farms brings out a point of much value. Farm No. 2, with an average of 16 cows on hand during the year, was operated by the owner with the aid of only \$50 worth of hired labor. He did not receive quite so large yields of his crops as were attained on farm No. 1, but he was able to grow more crops and at the same time take care of about all the cows the average man is willing to milk regularly. Of the 16 cows, presumably not all were in milk at any one time, or at least not for long. On the other hand, the farmer on No. 1 kept at least one hired man all the year and used much extra labor during the busy periods.

The one extra man would be required in most cases to help milk and care for the live stock on farm No. 1, where there are 20 cows and also a few more young cattle and many more hogs than on farm No. 2. At the same time this labor did not raise proportionately more crops either to feed or to sell than did the owner alone on farm No. 2.

In short, No. 2 is a good one-man farm, while No. 1 must be worked by two men on account of the live stock. These men are not employed on crops during the part of the day when they are not needed for the stock. To make farm No. 1 comparable to No. 2, the labor used on No. 1 should take care of about 30 cows and work the crops on about twice the acreage that they are now working. When the regular work, such as milking, is just a little too much for one man, it should either be reduced to what one man can do or work should be found to keep two men reasonably busy all the time.

FARM NO. 3.

TABLE IX.—*Statement of the business of farm No. 3.*

[Area, 150 acres; 50 tillable.]

CROP RECORD.

Crop.	Acreage.	Unit of yield.	Yield per acre.
Corn.....	2	Bushels..	50
Potatoes.....	1	do.....	150
Oats (fodder).....	2	Tons.....	2.5
Hay.....	40	do.....	.37
Clover.....	5	do.....	1

FINANCIAL STATEMENT.

Item.	Amount.	Total.
Capital.....		\$7,826
Real estate.....	\$7,000	
Machinery and tools.....	200	
4 cows.....	200	
1 horse.....	200	
20 chickens.....	13	
Other live stock.....	68	
Miscellaneous.....	145	
Receipts.....		587
Potatoes.....	65	
Apples.....	41	
Market milk.....	320	
Eggs.....	25	
Live stock (net).....	136	
Expenses.....		422
Labor.....	50	
Seeds.....	10	
Grain for feed.....	60	
Fertilizers.....	15	
All other cash.....	141	
Decreased inventory.....	146	
Farm income.....		165
Less interest at 5 per cent.....		391
Labor income.....		-226

The statement of farm No. 3 illustrates in many respects the average of the poorer 100 farms. It comprises a smaller total acreage and a little more tillable acreage than the average of the 100. The labor income of No. 3 is not so far on the wrong side as in the average of the 100. The principal reason for this is that this farm

is not doing so much business, and though it is badly managed the amount of mismanaged business is not sufficient to cause the loss shown as the average of the poorer 100.

If this farm had had more cows (10 being the number on the average of the poorer 100 farms), it evidently would have shown a worse statement of labor income than it did, provided, of course, the farm was managed on about the same basis as at present. With that condition it would have been nearly typical of the poorer 100 farms.

Compared with the two successful farms, Nos. 1 and 2, farm No. 3 illustrates why many farms in the regions surveyed do not yield a profit. The owner of this farm has just as many acres of tillable land as either of the other men, but he is not utilizing it. He is plowing so small a proportion of the tillable area each year that the rotation is a very long one and the result is a very low average yield of hay. This will neither feed a dairy herd economically nor allow any profitable cash crops to be grown to add to the income. The distribution of the capital on farm No. 3 also illustrates a common difficulty. This farmer estimated the value of his house at \$3,000, while the owner of farm No. 1 estimated his at \$2,000 and the owner of No. 2 at \$1,000. The house is a form of investment which does not contribute toward the income of the farm and the least successful of these three farmers had the most money in that item, while he had the least in the various forms of working capital, including live stock, tools and machinery, supplies, and cash to run the business. This farmer also considered his time worth \$500 per year, the same value which the owner of No. 1 placed upon his time. The owner of No. 2, however, set the value of his time at \$600 and, as we have already seen, was fully justified in doing so.

SUMMARY.

A summary of the striking points of comparison between the two groups of farms is as follows: The better 100 farms have a labor income of \$830 against a minus labor income of \$341 for the poorer 100.

The better farms have returned these larger profits with only 21 more acres of total area and about \$200 more total investment. Much less of the investment of the better farms was in real estate, however, and more of it in working capital.

The receipts of the better farms were much more than twice as great as those of the poorer farms, being greater in every class. On the other hand, the total expenses were nearly one-third greater, this increase being especially in a few items of productive expense, such as feeds and fertilizers.

The better farms kept one-half more cows and the same number of horses.

The better farms disclosed a markedly greater production per cow in money value, which would warrant a greater difference in the value of cows on the basis of production.

The better farms were operated by men 8 years younger, on an average, than those on the poorer farms and with much less help from other members of the family in farm work.

The more successful group of farmers is making more money, using only a little more capital and a few more acres and following much the same type of farming. While these factors—acreage and capital—have a little influence on the labor income in the regions studied, they do not seem to have so much effect as they have in some other regions studied in the same way. In such regions as these in New Hampshire, geographic conditions usually limit the acreage of tillage land a farmer can have in contiguous area, while the markets within his reach allow him to make considerable modification in his system of farming. Just the opposite limitations prevail in such a region as central Iowa, where it is much easier to get more adjoining land than it is to modify the system of farming.

The success of these better farmers in New Hampshire is due to more and better crops, more productive herds, and thus to more efficient use of their land and their time. The poorer farmers have more idle capital in the form of real estate which is not producing annual returns. Though part of this idle capital is in the form of buildings, much more is in the form of woodland, from which the return may come only at intervals of perhaps 20 or more years. The records of many of these farms do not fall on a year when these returns from wood were obtained. If these occasional receipts were distributed over the intervening years, there would be a tendency for the labor incomes of these poorer farms to be somewhat higher. The farm wood lot is a considerable source of income in these regions.

The comparisons given in this circular all indicate that the farmer in these sections of New Hampshire who makes a good income does so primarily by doing both more business and a better quality of business, although he had no better opportunities than were enjoyed by other men.

THE STRENGTH OF TEXTILE PLANT FIBERS.¹

By LYSTER H. DEWEY, *Botanist in Charge*, and MARIE GOODLOE, *Laboratory Assistant, Fiber Investigations*.

INTRODUCTION.

Tensile strength is the most important character of fibers used in making yarn, twine, thread, and woven goods. This one character must be combined with sufficient flexibility, fineness, length, uniformity of diameter, and smoothness to be suitable for spinning, but strength must be regarded as a prime factor.

In nearly all textile mills tests are made of yarns, twines, ropes, and also of woven goods made up of yarns, but very little has been done heretofore to actually measure the strength of individual raw fibers. A list of the "strongest fiber known" would fill several pages, and in the absence of accurate measurements superlative claims are reasonably safe from authoritative contradiction.

A paper² on the methods of testing fibers and giving the results of numerous tests of tensile strengths of single fibers was published in Java in 1908, but this excellent treatise in the Dutch language is little known in this country.

Many different kinds of machines have been devised for testing yarns, and some of these which are especially accurate in a low range are suitable for single fibers. A machine for testing cotton must be accurate in a range from 2 to 20 grams and one for testing long, hard fibers from 100 to 10,000 grams.

STRENGTH OF COTTON FIBERS.

More than a thousand samples of cotton fibers have been tested in the Office of Fiber Investigations. The machine (fig. 1) used in making these tests is based on the principle of balances, with a sliding brass bar instead of weights. The operator moves the bar steadily and without any jar by means of a thumbscrew which turns a ratchet wheel touching teeth on the bar. A single fiber picked up by the double forceps is placed in the jaws of the machine, the rounded faces of which, pressed together with springs, hold the fiber firmly but do not cut it. The weight is added by turning the thumb-

¹ Issued May 24, 1913.

² Havik, H. G. *Laboratorium voor het onderzoek van vezelstoffen*. Jaarboek, Departement van Landbouw, Nederlandsch-Indië, 1908, p. 319-333, 2 pl., 1909.

screw with a uniform motion, and the breaking strain is read on the dial in tenths of grams. Twenty fibers are thus broken, one at a time. The breaking strain of each is recorded, showing the variation, and the average is determined as the tensile strength of the sample.

While there is much variation in every sample, it has been found by numerous trials that the average breaking strain of 20 fibers is approximately the same as that of a larger number. This is espe-

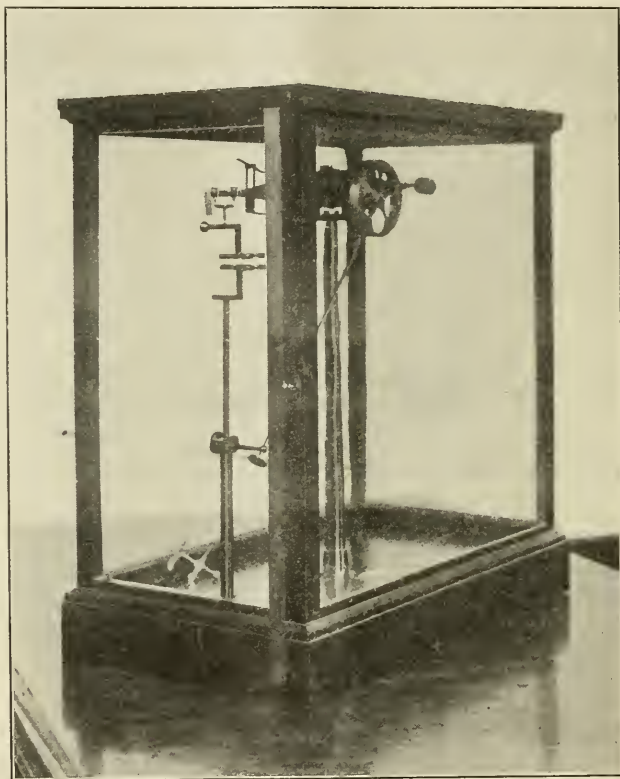


FIG. 1.—Fiber tester, with a capacity of 0.1 to 50 grams, used for determining the strength of cotton fibers.

cially true of seed cotton, where it is possible to take one fiber from each of 20 different seeds. Furthermore, it is found that the fibers taken from midway on the side of the seed are more uniform than those at either end. Those at the pointed end are most variable.

The results from a large number of tests of samples from nearly all of the prominent varieties in the seven different groups of American Upland cotton, and also Sea Island and Egyptian cottons, are condensed in Table I.

TABLE I.—*Tensile strength of cotton fibers.*

Variety of cotton.	Breaking strain (grams).		
	Highest.	Lowest.	Average.
American Upland (<i>Gossypium hirsutum</i>):			
Big-Boll Stormproof group.....	9.0	5.2	6.67
Big-Boll group.....	11.6	4.6	6.60
Cluster group.....	7.7	5.1	6.00
Semicluster group.....	7.1	4.7	5.86
Peterkin group.....	6.0	5.0	5.70
Early group.....	6.9	5.2	5.63
Long-staple group.....	5.6	3.5	4.72
Sea Island (<i>Gossypium barbadense</i>).....	7.6	4.7	6.14
Egyptian (<i>Gossypium barbadense</i>):			
From Arizona and California.....	8.0	5.6	6.65

The highest and lowest figures given in the foregoing table are the averages for 20 fibers, not the highest and lowest breaking strain of single fibers. The tensile strength of single fibers of American Upland cotton is generally in inverse ratio to their length, though the longer staples make stronger yarns. The strength is in more direct ratio to the diameter. The accurate measurement of the diameters of the twisted, ribbonlike cotton fibers presents such difficulties and requires so much time that it is not included in all tests. Measurements by means of a microscope with an eyepiece micrometer have been made of more than 100 samples. A summary of these measurements is shown in Table II.

TABLE II.—*Diameters of cotton fibers.*

Variety of cotton.	Diameter (microns). ¹		
	Maxi- mum.	Mini- mum.	Average.
American Upland (short staple).....	34.80	28.80	31.88
Sea Island.....	28.10	21.75	24.31
Egyptian (American grown).....	28.10	18.40	23.30

¹ 1 micron=0.001 millimeter, or nearly 0.00004 inch.

A series of tests has also been made to determine the pull necessary to detach the fiber from the seed. In American Upland varieties this ranges from 1.88 to 2.3 grams, and in Sea Island from 1.75 to 1.95 grams.

STRENGTH OF LONG FIBERS.

The long fibers constitute two natural groups: (1) Soft fibers, or bast fibers, such as flax, hemp, jute, and ramie; (2) hard fibers, such as abacá (Manila hemp), henequen, sisal, and phormium (New Zealand hemp). The strands of the soft fibers vary greatly in thickness and they usually cling together in such a manner as to make it practically

impossible to select single strands for comparison. The hard fibers, however, present single strands sufficiently uniform and free from other strands to be selected for breaking, but they are not uniform enough to be directly compared. A coarse, hard fiber may break at a higher tensile strain than a finer one, yet the fine one may be much stronger when compared with equal bulk or weight for weight. Weight is more satisfactory for comparison than diameter or bulk and it is more easily determined. For comparison, therefore, the breaking strain of each sample is computed to the convenient but arbitrary standard of a fiber weighing 1 gram per meter of length.

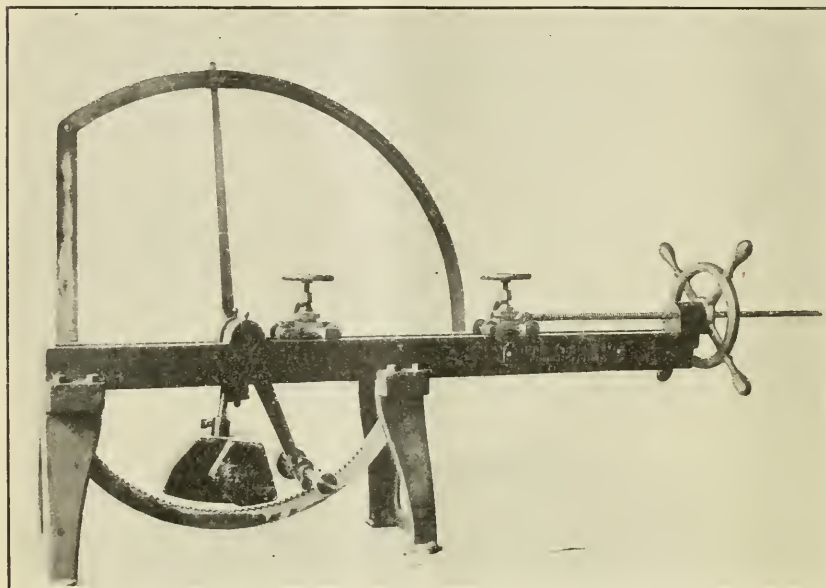


FIG. 2.—Testing machine with a capacity of 1 gram to 90 kilograms, used for determining the strength of hard fibers.

In testing hard fibers the following method is pursued:

Twenty fibers are selected from the sample and their length measured, after which they are weighed and the total weight is divided by the total length, giving the average weight per meter. They are then broken, one at a time, in the testing machine. (Fig. 2.) The average breaking strain divided by the average weight per meter gives the breaking strain per gram meter.

The results of numerous tests of some of the principal hard fibers are given in Table III.

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TABLE III.—*Weight and breaking strain of hard fibers.*

Fiber.	Weight per meter.	Average breaking strain per strand.	Breaking strain per gram meter.
Abacá (Manila hemp), <i>Musa textilis</i> :	<i>Gram.</i>	<i>Grams.</i>	<i>Grams.</i>
Highest.....	0.04019	3,020	75,143
Lowest.....	.06817	2,012	29,521
Average.....	.05470	2,254	45,115
Henequen (Yucatan sisal), <i>Agave fourcroydes</i>	.05420	1,085	20,021
Sisal (Hawaii and East Africa), <i>Agave sisalana</i>	.04370	1,472	32,773
Cantala (Manila maguey), <i>Agave cantala</i>	.03040	625	2,055
Phormium (New Zealand hemp), <i>Phormium tenax</i>	.04670	1,222	26,159
Zapupe Vincent (<i>Agave lespinassei</i>).....	.05120	1,394	27,198
Cabuya (from Costa Rica), <i>Furcraea cabuya</i>	.04070	1,297	31,933

Several different grades of abacá are recognized in the market, the differences being due chiefly to greater or less care in cleaning the fiber, and therefore this fiber presents a wide variation in weight per meter and in strength. The highest and lowest figures given in the foregoing table do not represent the extreme limits. Henequen and sisal cleaned by machinery are more uniform.

[Cir. 128]

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 129.

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

- The Present Status of Date Culture in the Southwestern States WALTER T. SWINGLE
The Present Status of the White-Pine Blister Rust PERLEY SPAULDING
The Work of the Umatilla Experiment Farm in 1912 R. W. ALLEN
-

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Issued June 7, 1913.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

BUREAU OF PLANT INDUSTRY.

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Assistant Chief of Bureau, L. C. CORBETT.
Editor, J. E. ROCKWELL.
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THE PRESENT STATUS OF DATE CULTURE IN THE SOUTH-WESTERN STATES.¹

By WALTER T. SWINGLE, *Physiologist in Charge of Crop Physiology and Breeding Investigations.*

It has been demonstrated by the work of the Department of Agriculture and the numerous date growers cooperating with it that the growing of standard varieties of dates, such as the Deglet Noor, by resident farmers in hot, dry, irrigated valleys is a very promising new line of fruit culture.

The satisfactory outcome of the experiments of the Bureau of Plant Industry in establishing the commercial culture of the date palm in the Coachella and Imperial Valleys has aroused much interest in date growing on a commercial scale. While the new industry has a very promising future if kept on a reasonable basis, unwarranted claims, such as are now being made by parties in some speculative enterprises, are bound to lead to great disappointment on the part of uninformed purchasers and are likely to jeopardize the future of the date industry and to hinder seriously the proper development of those regions best adapted to date culture.

It should be clearly borne in mind that date culture is a new industry, requiring experience and unusual skill on the part of the grower, and that it must be carried out in regions having an extremely hot summer climate—two causes which greatly increase the expense and risk of date culture to nonresident owners and corporations. The profits of date culture are almost impossible to estimate in advance, and the claims made on this point in many instances have been unintentionally exaggerated, especially since date culture as it now exists is supplemental to other types of farming. Further development and better organization of the date industry, both in regard to growing and to marketing, are needed before dates can safely be grown as the only crop. Any calculation as to the probable profits of date culture is of very little value, since this industry is new, little understood, and demands unusual knowledge and skill on the part of the grower.

It often happens that one of two adjoining orange orchards yields a very handsome profit even on land having a very high valuation,

¹ Issued June 7, 1913.

while the other with identical soil and climatic conditions is run at a loss to the owner. How much more is this likely to be the case in growing the date palm, which, unlike the orange, is a new crop plant and only imperfectly understood.

In particular, many nonresident owners or stock companies are at present very poorly equipped to carry on this industry with any certainty of success, since there are only a few competent managers to be had who understand date culture and who are able to endure the trying summer climate of the date-growing regions. It must be remembered that the planting of untested varieties is a very risky matter. The date palm, unlike all other commonly grown fruit trees, can not be budded or grafted, and if by any chance the variety planted proves to be not adapted to the soil or climate there is no remedy but to dig up the trees and either sell them at a sacrifice or, more probably, destroy them outright.

When we remember that offshoots of good varieties cost from five to ten times as much as grafted plants of other fruit trees and that to establish them in the field amounts to the rooting of a cutting in open ground, which is a very costly operation requiring great skill and the most scrupulous attention, we realize that to bring date palms into bearing costs very much more per acre than to grow any other orchard crop.

It is then obvious that growers who have only a limited capital to invest can scarcely afford to experiment with untested varieties. It is not enough that the varieties should be valuable in their native country, and it is not even enough that they should fruit successfully in this country. It must be proved that their culture can be carried on commercially with a reasonable certainty of success. Many otherwise desirable date varieties do not cure well, and consequently are hard to market. Each date variety must be studied most carefully over a term of years before its culture on a commercial scale can be recommended.

At present less than a dozen varieties among the 200 or more on trial at the Government date gardens in the Southwest can be said to be well enough known to warrant planting on a commercial scale. The Deglet Noor and the Tazizaoot can be recommended for orchard planting in the Coachella and Imperial Valleys of California; the Halawi, the Khadrawi, the Maktum, and the Birket el Hadji are promising for cooler regions, such as the Salt River Valley of Arizona, and may be planted in the California date regions on a scale not too large for the early markets; the Rhars is excellent for home use as a fresh date, but is of little commercial value; the Thoory¹ is a dry

¹ There are at least two distinct dates known by this name in Algeria, and only one, apparently the more uncommon one, is promising.

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date of great promise, but it is as yet doubtful whether dry dates can be marketed advantageously on a large scale without an expensive publicity campaign.

It must be clearly understood that to plant other varieties that are new or inadequately tested involves a considerable element of risk. The fact that they appear satisfactory in the Old World deserts is no guarantee that they will grow, bear, and ripen fruit properly in the Southwest or that their fruit will prove acceptable to American buyers. Any planting of a variety on a large scale before it has been thoroughly tested must be considered as a speculation, since the planter runs the risk of finding out that the variety is unsuited to his conditions. Those having the means and the interest to test out such little-known varieties under as many different soil and climatic conditions as possible will render a valuable service to their community.

It would be much safer for those who expect to grow dates on a commercial scale to limit themselves at first to those varieties that have been tested by the Department of Agriculture and to learn all phases of the culture, curing, packing, and marketing of the fruit of one or more of the standard varieties. This is the best possible preparation for the efficient culture of new sorts when they have been tested enough in the Government or other adequately supervised testing gardens to render it desirable to test them on a commercial scale in private culture.

Much misinformation has been spread in regard to seedling dates. For some years the Department of Agriculture has been furnishing gratis seeds of choice dates to bona fide date growers so that the latter could at slight expense familiarize themselves with the culture of date palms. Up to June, 1911, imported offshoots were offered as a bonus to those who set out seedling dates in prescribed form. In this way it was possible for a farmer to learn date culture and even to obtain offshoots of choice imported varieties at little or no cash outlay, since it was possible to set out a seedling date orchard by plowing up and planting to dates narrow strips in fields planted to alfalfa or other field crops.

The quality of the seed distributed by the Department of Agriculture has steadily improved as it became possible to use pedigreed male palms in pollination of the date palms that furnished the seed. It is hoped in the case of the Deglet Noor that the Department will be able in a few years to supply seed of the best attainable breeding quality—i. e., giving the highest attainable percentage of seedlings of the Deglet Noor type.

Every grower of seedling dates has a chance of originating new and superior varieties, though it must be said that only a very small percentage of the seedling dates are good enough to warrant propagating the variety. Already a number of valuable seedling dates have been

originated in the Salton Basin, and doubtless many more will come to light within the next few years when the tens of thousands of seedling dates now being grown come into full bearing. Another very important advantage of seedling dates is that if kept properly isolated from imported date palms they are absolutely free from the *Parlatoria* and *Phoenicococcus* scales that infest most, if not all, the imported palms.

Seedling dates, however, are very poorly adapted to familiarizing the grower with the best methods of curing, packing, and marketing. As every tree is different, the crop varies greatly in quality and time of ripening and it is practically impossible to put any standard brands on the market. The proper marketing of dates can be learned much more easily by the grower of standard varieties propagated from offshoots. Every seedling date grower should plant as soon as possible an orchard with offshoots of Deglet Noor or other standard variety adapted to his conditions, so he can familiarize himself with the vitally important processes of curing, packing, and marketing dates.

On the other hand, every grower of imported dates should plant a seedling date orchard in the hope of originating valuable new varieties, to secure a supply of male trees to supply pollen, and to have plants upon which to experiment in transplanting, cutting offshoots, etc. Any proposal to grow seedling dates alone on a commercial scale as a source of profit is, to say the least, premature.

It must be said that any form of date culture is at present a risky business to the man who is not himself thoroughly acquainted with the local conditions and experienced in date culture as well. Non-resident owners, even though they plant offshoots of the best tested varieties, are at the mercy of their managers, and, as stated before, there are at present very few experienced managers who understand date culture well enough to be able to manage a commercial date plantation successfully.

To summarize, date growing is a new and promising but unusually difficult branch of fruit culture. It is most promising to the small resident owner who, by experimenting with seedling dates and a small planting of offshoots, has acquired the necessary experience to enable him to care for young date palms efficiently. Commercial plantings should be made only of tested standard varieties, such as the Deglet Noor, Tazizaoot, Birket el Haggi, and possibly one or two other varieties. If a wrong variety is planted great loss is entailed, as the trees can not be budded or grafted over into better varieties, but must be dug up and destroyed.

Seedling dates are useful to the beginner in giving him experience in handling date palms, in furnishing male trees for pollinating the

bearing trees, and also in giving rise to a very small percentage of new valuable varieties. Seedling dates, if grown alone, are not adapted to commercial culture but should be grown along with orchard plantings of standard varieties, which alone can be cured, packed, and marketed efficiently.

Extensive plantings of seedling dates alone should be made only by those having capital enough to afford to carry the plantation for a long time without profit. Nonresident investors should beware of seedling date culture as a commercial proposition.

The necessity of calling attention to the danger of loss through planting inadequately tested date varieties or large-scale planting of seedling dates must not be allowed to obscure the fact that there is a prospect and a bright one for the establishment of a new and profitable orchard crop. Indeed, the present warning has been rendered necessary by the very fact that date growing offers very unusual advantages to farmers residing in certain valleys of the Southwest and making a living by the culture of other crops, which has led to hopes, for the most part unwarranted, on the part of nonresidents to secure large profits by engaging in this industry, about which they know little except through biased accounts issued by promoters. The attempt by nonresidents to reap anything like the same advantages from date culture is very likely to lead to disappointment and failure and so tend to discredit a promising new fruit industry.

THE PRESENT STATUS OF THE WHITE-PINE BLISTER RUST.¹

By PERLEY SPAULDING, *Pathologist, Investigations in Forest Pathology.*

INTRODUCTION.

Since the publication in 1911 of Bulletin No. 206 of the Bureau of Plant Industry, entitled "The Blister Rust of White Pine," considerable new information has been obtained concerning the blister rust and the fungus that causes it. This is of such a nature that it is thought best to publish it at once, so that the various persons who have to deal with the disease may have the fullest information possible with which to carry on their work.

FIELD CHARACTERS OF THE DISEASE.

In previous publications upon this subject² the writer has described those symptoms of the disease that seem to be distinctive and that are evident without the use of a microscope, that is, the "field characters" by which inspectors must recognize it. Those symptoms which were first recognized follow: (1) The presence of the fruiting bodies of the fungus and the cavities in the bark where they have been recently borne, (2) the stunted growth and compact appearance of the tops of badly diseased trees 3 to 5 years old, (3) the roughened, scaly bark on stems which bore fruiting bodies in previous years (see fig. 1 for healthy stem), (4) the abnormal swelling of affected stems of trees usually less than 6 years old, and (5), rarely, the local dying of the bark more or less completely around the young stem of trees 3 or 4 years old. Later an additional and more uncommon symptom was described by the writer,³ namely, a coarse yellow mottling of the leaves and bark on the affected portion of trees which have shown the disease the previous year and which are about to die. This symptom has been mentioned by Klebahn⁴ as occurring upon the needles of trees artificially inoculated with teleutospores of the fungus;

¹ Issued June 7, 1913.

² Spaulding, Perley.

(a) European currant rust on the white pine in America. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 38, 4 p., 1909.

(b) *Peridermium Strobi* Klebahn in America. Science, n. s., v. 30, no. 763, p. 200-201, 1909.

³ Spaulding, Perley. Notes upon *Cronartium ribicola*. Science, n. s., v. 35, no. 891, p. 146-147, 1912.

⁴ Klebahn, H. Kulturversuche mit Rostpilzen. XII. Bericht (1903 und 1904). Zeitschrift für Pflanzenkrankheiten, Bd. 15, Heft 2, p. 87, 1905.

also by Pechon¹ on leaves of diseased trees in the open forest. Recently another symptom which is rather common has been noted on trees 5 or more years old. This is the dying of one or more of the lowest lateral branches which are located within the affected area on the stem of the tree. The dead branches are usually abnormally swollen at the base.

The stunted, compact appearance of the top is by no means a constant symptom of the disease. In a diseased lot of 10,000 trees 8 years old the writer could detect no difference in growth between apparently healthy trees and those which bore fruiting bodies by the hundred but which apparently bore fruiting bodies in 1912 for the first time. The stunting usually shows mostly in stock that is 4 and 5 years of age.

It can not be expected that any one or all of these symptoms will be found in all the trees affected with this disease. The swelling of the bark is the most constant symptom, but it may be lacking, while some other symptom is evident enough to show the presence of the disease in a suspected lot of trees.

There is some danger of confusing the roughened bark caused by the attacks of colonies of the insect *Chermes pinicorticis* Fitch with the roughening caused by the blister rust. There is a decided difference between the two forms of roughening. In the former the bark is very irregularly cracked and fissured and there is usually some evidence of the insects themselves (figs. 2 and 3). In the



FIG. 1.—Stem of young, healthy white-pine tree. Note the smooth bark.

latter form (caused by *Cronartium ribicola*) the bark is usually fissured more deeply and many of the cracks extend horizontally (figs. 4 and 5). With the former the bark scales are rather thin, while with the latter they are apt to be decidedly thicker and heavier.

There can be no doubt that this fungus will establish itself here if allowed to do so. The writer has mentioned² the discovery of uredospores on *Ribes* leaves in one case where *Ribes* was near

¹ Pechon, L. Principales maladies des arbres et des peuplements forestiers. Bulletin, Société Centrale Forestière de Belgique. Ann. 14, libr. 6, p. 329-330, 1907.

² Spaulding, Perley. The blister rust of white pine. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 206, 88 pp., 5 figs., 2 pls., 1911.

diseased pine trees and where the fungus evidently transferred from the pines to the *Ribes*. In 1912 four cases of its occurrence upon *Ribes* were found in as many different States. Apparently the crisis with this disease is at hand and whatever measures are to be taken for its thorough eradication must be well started during 1913 or it will become permanently established here. It has been

found that plants of *Ribes* are reestablishing themselves where they were removed in 1909.

The disease is reported as having been found for the first time in the State of Rhode Island upon white pines.

ORIGIN OF DISEASED STOCK.

In a previous publication¹ the writer stated that the white-pine blister rust has been reported as having been received in this country in white-pine stock sent by J. Heins' Sons, of Halstenbek, Germany; Levavasseur & Son, of Ussy, France; Barbier & Co., of Orleans, France; and E. T. Dickinson, of Chatenay, France.

In the spring of 1912 Dr. W. E. Britton, the State entomologist of Connecticut, informed us of the discovery of this disease in a shipment of 3-year-old white pines from the Union Nurseries, Schaum & Van Tol, of Oudenbosch, Holland.² This shipment, moreover, entered the country under the certificate of the Phyto-



FIG. 2.—A 4-year-old white-pine tree with chermes causing scaly bark. The chermes are still present, the white areas being their colonies.



FIG. 3.—A 4-year-old white-pine tree with chermes causing scaly bark. The chermes have died out. At the left and below is the scar caused by some mechanical injury.

pathological Service of Holland. At about the same time Dr. H. T. Fernald, nursery inspector and State entomologist of Massachusetts, reported the discovery of the disease in stock received from Buch & Hermansen, of Halstenbek, Germany, and submitted specimens for verification of his identification of the fungus. Further, the

¹ Spaulding, Perley. The blister rust of white pine. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 206, 88 pp., 5 figs., 2 pls., 1911.

² Clinton, G. P. Plant diseases of Connecticut. Connecticut Agricultural Experiment Station, Report, 1912, p. 347-348.

writer in 1912 found the disease in a lot of white pines sent to this country by Buch & Hermansen in 1909, at which time the trees were apparently healthy.

INEFFICIENCY OF INSPECTION EVEN WHEN REPEATED.

In earlier publications¹ the writer has repeatedly called attention to the fact that a single inspection of a lot of white pines diseased with the blister rust will not result in the complete eradication of the infected trees. The inefficiency of inspection even when repeated, except as a temporary expedient, has become increasingly evident from the beginning in 1909, when the disease was first discovered here on pines. It has been found by personal investigations that the closest inspection possible will not remove all infected trees in a single large lot of trees.² That is, plainly diseased trees were found in 1910 and 1911 in a lot of 10,000 white pines which were in 1909 very closely inspected and from which all suspicious trees were then removed and destroyed. Moreover, after three personal inspections in previous years this lot of trees was found in 1912 to have quite a number which bore abundant fruiting bodies.

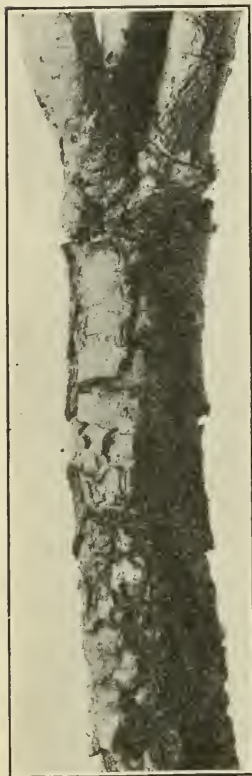


FIG. 4.—White-pine tree about 10 years old which has borne blister-rust fruiting bodies in previous years. Note the heavy scales of bark on a stem which at this age should be smooth.

Another parallel case is that of another lot of 10,000 white pines, imported when 3 years old. These were inspected in 1910 by a State official who knew the disease well. About 150 were removed and burned at that time, including every doubtful tree that was found. The *Ribes* plants in that locality were also pulled up and burned; there were but two, and these showed no signs of the disease. In 1912 re-inspection showed that about 30 of the remaining trees bore very abundant fruiting bodies of the fungus. Many of the diseased

¹ Spaulding, Perley.

(a) The blister rust of white pine. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 206, 88 p., 5 fig., 2 pl., 1911.

(b) Notes upon *Cronartium ribicola*. Science, n. s., v. 35, no. 891, p. 146-147, 1912.

(c) ——— and Field, Ethel C. Two dangerous imported plant diseases. U. S. Department of Agriculture, Farmers' Bulletin 489, 29 p., 3 fig.

² Spaulding, Perley. Notes upon *Cronartium ribicola*. Science, n. s., v. 35, no. 891, p. 146-147, 1912.

trees had hundreds of distinct spore bodies. There was no evidence of these trees having been infected since reaching this country. The affected area was just below the lower branches, where it nearly always is found in newly imported trees bearing fruiting bodies of the fungus when received at the port of entry. These trees had not borne fruiting bodies in previous years, since the bark of the affected area was not scaly, as it is where fruiting bodies have previously been produced, and, furthermore, since all visibly diseased trees had been destroyed in previous years. So far as could be ascertained the disease had lain dormant for five years in these trees, only to break out with the most profuse production of fruiting bodies yet seen in this country.

In 1909¹ the writer concluded, from data afforded by numerous papers of European writers (which was the only available information), that inspection of diseased plantations for a few years might result in the final eradication of the disease, and this procedure was recommended rather than the more drastic one of total destruction of infected plantations. Since that time personal investigations, such as above described, have indicated that this procedure is not proving as effective as desired.

In the light of the above results it seems best to recommend the total removal and destruction of diseased plantations wherever possible. It is recognized that there are diseased plantations which it may be impossible to destroy, but these are few in number. Mere unwillingness or temporary inexpediency should not be substituted for impossibility in considering this matter. This does not necessarily mean that every plantation must be destroyed in a single year. The values involved and the number of trees are so large that it would be unwise for those States which have the largest numbers to undertake to replace all the diseased plantations in one year. It is believed that the removal of diseased plantations can be done gradually, those which are worst being taken first. It should especially be done where *Ribes* occurs in the vicinity of the diseased plantations. Much danger would thus be eliminated. In many cases the cost of



FIG. 5.—A 5-year-old white-pine tree, showing scaly bark caused by the blister rust.

¹ Spaulding, Perley.

(a) European currant rust on the white pine in America. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 38, 4 p., 1909.

(b) *Peridermium Strobi* Klebahn in America. Science, n. s., v. 30, no. 763, p. 200-201, 1909.

(c) Notes upon *Cronartium ribicola*. Science, n. s., v. 35, no. 891, p. 146-147, 1912.

continued inspection will more than replace the diseased plantations with healthy trees and this policy would be more economical to the State than to continue inspection. The national quarantine law prevents further importations of this disease, thus removing a great uncertainty regarding its status. At least three of the States—New Jersey,¹ New York,² and Connecticut³—have already destroyed entire shipments of white pines when the disease was found in them. The destruction of infected plantations is the logical continuation of this policy. It will rid the country of the disease and is apparently the only sure method of doing so.

VARIATIONS IN FRUITING.

This fungus apparently varies much in the abundance of fruiting bodies formed in different years.⁴ There can be little doubt that weather conditions are largely responsible for this variation. In 1911 relatively few diseased trees were found bearing fruiting bodies of the fungus, but in 1912 a large number were found with them, even in plantations which had been carefully inspected before and from which all the diseased trees were removed and destroyed one or more years ago. Moreover, the trees which bore fruiting bodies in 1912 had them in great profusion, some trees being found which bore hundreds of peridia. This experience was quite general wherever careful inspection of diseased plantations was made.

A comparison of the monthly weather reports for the two years shows the following conditions for New York and New England: In March, 1911, the precipitation for some time had been so low that many city and town water supplies were very low, so much so as to cause serious apprehension. The precipitation for March, 1911, was slightly less than normal; for April it was very light and the weather was sunny; for May the precipitation was hardly half of the normal amount. These conditions the writer believes materially hindered the formation of fruiting bodies by the rust. In 1912 the conditions were quite different. The drought which prevailed in the spring of 1911 was broken, and water supplies began to assume their normal condition. In March, 1912, precipitation was very heavy, more than counterbalancing what the previous two months had lacked; April had excessive precipitation and cloudy weather, May had heavy precipitation, while June was somewhat deficient. Abundant precipitation just before the fruiting period, and even at that time,

¹ (Anonymous.) Forest Quarterly, v. 9, no. 2, p. 351-352, 1911.

² (Anonymous.) Op. cit., p. 359, 1911.

³ Britton, W. E., and Walden, B. H. Inspection of imported nursery stock in Connecticut. Connecticut Agricultural Experiment Station, 12th Report, 1912, p. 222.

⁴ Hawes, A. F. Suppression of white-pine blister rust disease. 4th Annual Report, State Forester, Vermont, p. 21-24. In Agriculture of Vermont, 1912.

seems to favor the fruiting of the fungus. Probably the suppression of fruiting bodies in 1911 had something to do with their abundance in 1912.

A number of European writers have definitely mentioned the time when this fungus fruits upon pines, their dates varying from March 19 to July 7. Very evidently the character of the location and season largely governs the date of fruiting. However, it has been found that this rust fruits earlier than most of the tree rusts. In this country *Cronartium ribicola* has been found in fruit upon pines from early April to early July, the time varying with the earliness of the spring, the warmth of the location, the altitude, and the elevation. Upon comparing this species with native species of *Peridermium* of the same district it is found that the white-pine blister rust fruits somewhat earlier than these species of *Peridermium*. That is, when the latter are in full fruit the white-pine blister rust is already past its maximum season, and if its fruits occur at all they are scattering, belated cases. So far as the writer's observations go, this is approximately true of all situations and localities. This may explain why this disease was not observed on pines until 1909, although it must have been in the country in small quantities before that year. One of the most prominent European mycologists¹ has plainly stated that this is decidedly earlier in Europe than other native species of *Peridermium*.

DISTANCE SPORES ARE DISTRIBUTED.

Some observations recently made by the writer² upon *Cronartium comptoniae* Arthur are interesting as indicating in a general way the distance that the two hosts of the white-pine blister rust must be separated in order to prevent the spread of the fungus from pines to *Ribes*. In localities where *Pinus rigida* Mill. and *Comptonia asplenifolia* Gaertner were growing in close proximity to each other it was found in June that the uredo stage of *Cronartium comptoniae*, which was then quite abundant, was present on the latter host within only a few yards (usually within 10 yards) of a diseased pine tree. That is, the æcidiospores on pines were apparently blown but short distances from their source. How far occasional spores may be blown is entirely problematical, as no good opportunity has yet been seen for getting evidence along this line. The æcidiospores of *Cronartium comptoniae* and of *C. ribicola* are so similar in size, shape, and general characters that it seems likely that what is true of the mechanical distribution of one will be essentially true

¹ Klebahn, H. Weitere Beobachtungen über die Blasenroste der Kiefern. Berichte, Deutsche Botanische Gesellschaft, Bd. 6, pp. XLV-LV, 1888.

² Spaulding, Perley. Notes on *Cronartium comptoniae*. Phytopathology, v. 3, no. 1, p. 62, 1913.

for the other. This might indicate that under ordinary conditions the white-pine blister rust will infect *Ribes* for a distance of about 10 yards from a diseased pine tree. But how far a really hard wind or a small whirlwind may carry these spores is entirely unknown.

It should be mentioned that in the vicinity of Geneva, N. Y., in 1912, the uredospores of *Cronartium ribicola* were apparently blown a distance of nearly half a mile, as some of the diseased *Ribes* were that distance from other known diseased *Ribes*.¹

HOW THE FUNGUS IS CARRIED FROM ONE PLACE TO ANOTHER.

It has been generally supposed that the white-pine blister rust is carried from one locality to another only by means of infected white-pine trees. This is undoubtedly the way the disease reaches new localities in the majority of cases. European writers² have mentioned this as if it were the only means of transference of the disease and some even state that *Ribes* bushes, which were diseased one year did not show the disease the next year.³ So far as we can find, few European writers have seriously considered that the fungus might be carried considerable distances except by means of diseased young pine trees, although some⁴ have noted the absence of pines from the neighborhood of diseased *Ribes* bushes.

The experience in this country, however, seems to indicate that the fungus may be occasionally carried on dormant *Ribes* stock, and this possibility was suggested by Stewart in 1906⁵ and by the writer in 1911.⁶ Occurrences of the disease upon *Ribes* where its origin could not be traced to diseased pines led to this assumption as a possible explanation of its otherwise inexplicable presence.

¹ Stewart, F. C., and Rankin, W. H. *Cronartium ribicola* and the proscriptio of *Ribes nigrum*. (Abstract.) *Phytopathology*, v. 3, no. 1, p. 73, 1913.

² Tubeuf, Carl von.

(a) Vernichtung des Weymouthskiefernröstes. *Praktische Blätter für Pflanzenschutz*, Jahrg. 1, Heft 8, p. 63, 1898.

(b) Ueber die Verbreitung von Baumkrankheiten beim Pflanzenhandel. *Mitteilungen, Deutsche Dendrologische Gesellschaft*, p. 156-163, 6 fig., 1904.

Klebahn, Heinrich. *Die Wirtwechselnden Rostpilze*. Berlin, 1904, p. 382-387.

³ Hennings, P. Ueber das epidemische Auftreten von *Cronartium ribicola* Dietr. im Dahlemer botan. Garten. *Notizblatt, Königl. Botanischen Garten und Museum*, Berlin, Bd. 3, no. 28, p. 172-175, 1902.

Fischer, Ed. Beiträge zur Kenntniss der schweizerischen Rostpilze. *Bulletin de l'Herbier Boissier*, t. 6, no. 1, p. 16-17, 1898.

Jaczewski, A. A. Ezhegodnik svjedenij o bolezniakh i povrezhdenijakh kul'turnykh i dikorastushchikh poleznykh rastenij. *God.* 3, p. 142-143, 1908.

⁴ Klebahn, Heinrich. *Die Wirtwechselnden Rostpilze*. Berlin, 1904, p. 382-387.

Bondartseva, A. S. Rastitel'nye parazity kul'turnykh i dikorastushchikh rastenij sobrannye v Kurskoj gubernii lietom 1901, 1903-1905 godov. (Les parasites végétaux des plantes cultivées et sauvages, recueillis dans le gouvernement de Koursk en 1901, 1903-1905.) *Acta Horti Petropolitani*, t. 26, p. 19, 1906.

Iwanoff, K. S. Die im Sommer 1898 bei Petersburg (Russland) beobachteten Krankheiten. *Zeitschrift für Pflanzenkrankheiten*, Bd. 10, Heft 2, p. 99, 1900.

Hennings, P. *Loc. cit.*

⁵ Stewart, F. C. An outbreak of the European currant rust (*Cronartium ribicola* Dietr.). *New York State Agricultural Experiment Station, Technical Bulletin* 2, p. 61-74, 3 pl., 1906.

⁶ Spaulding, Perley. Notes upon *Cronartium ribicola*. *Science*, n. s., v. 35, no. 891, p. 146-147, 1912.

In 1911 the writer secured the only direct evidence that the fungus may be carried on dormant *Ribes* stock that has yet been published. This was the discovery of a single leaf upon an artificially inoculated *Ribes* bush which had the telial stage upon the petiole (fig. 6) and even on the slight stipules at its base. The statement¹ concerning it read:

The finding of the teleuto stage of the fungus affecting the stipule and bracts of a *Ribes* leaf in the greenhouse is believed to practically prove that the fungus may sometimes attack the bud scales of dormant bushes and cuttings; this very probably explains the anomalous appearance of this fungus in this country upon *Ribes* at Geneva, N. Y., and possibly in Kansas.

It was intended to say: "The finding of the teleuto stage of the fungus affecting the petiole and stipules * * *," but by some

mistake it read as above quoted. While this is not complete proof that the fungus may occasionally attack the bud tissues by way of the petiole, such proof has been sought by the writer and is still being sought, not only in independent experiments but also in experiments in cooperation with



Fig. 6.—*Ribes* petiole showing telial stage of *Cronartium ribicola* progressing downward from the leaf blade. (Drawn in dry condition with a camera lucida.)

the New York State Agricultural Experiment Station.

LEGISLATION.

The various States of this country have as varied laws against plant diseases as could well be devised. They range in efficiency from zero to nearly perfect. A number have laws authorizing the proper State official to declare and enforce quarantine against especially dangerous plant diseases. This power has been used in but few cases, however. In 1912 the nursery inspector of Massachusetts prohibited any further importation of any 5-leaved pine stock from Europe into that State because of the white-pine blister rust. This order took effect June 1, 1912.

Soon afterward the Sixty-second Congress, in its second session, passed the bill previously known as the Simmons bill for the regulation of the importation of nursery stock, etc. This was approved and became the official "Plant Quarantine Act, August 20, 1912," this being the short title for it. This is the only national legislation for this purpose which has ever been enacted. Because it applies to the white-pine blister rust and is so recent, a brief statement of its essential features will be useful.

Section 1 provides for the importation of nursery stock only under permit from the Secretary of Agriculture. A foreign certificate of

¹ Spaulding, Perley. Notes upon *Cronartium ribicola*. Science, n. s., v. 35, no. 891, p. 146-147, 1912.

inspection is also required. Such permit must be granted when the requirements are fulfilled. Nursery stock may be imported for experimental or scientific purposes by the Department of Agriculture. Where a foreign country has no inspection service nursery stock may be admitted under the regulations of the Secretary of Agriculture.

Section 2 requires the customhouse officials to notify the Secretary of Agriculture of the arrival of nursery stock at the port of entry; also a similar notification by the person receiving the stock at port of entry before removing it or shipping it to any other point, which notification shall also be sent to the proper official of the State to which such stock is destined. This notification must give the name and address of the consignee, the nature and quantity of stock to be shipped, and the country and locality where the stock was grown, unless such stock has been inspected by the proper State official.

Section 3 provides for the plain and correct labeling of the stock offered for entry, so that the nature and quantity of stock, the country and locality where grown, and the name and address of the shipper and consignee may be determined.

Section 4 provides for similar labeling of interstate shipments, unless they have already been inspected by the proper State official.

Section 5 gives the Secretary of Agriculture power to quarantine particular plants or plant products not included under "nursery stock" when necessary in order to exclude diseases or insects dangerous and new to this country. A public hearing shall be given before such orders shall take effect.

Section 6 defines nursery stock.

Section 7 provides for quarantine of plants or plant products from foreign countries or localities, regardless of the use to which they are to be applied. A public hearing shall be given before an order takes effect. The provisions of this section apply to the white-pine blister rust, potato wart, and Mediterranean fruit fly from the passage of this act.

Section 8 provides for quarantine of any State or locality in this country to prevent the spreading of dangerous diseases or insects which are new or not previously widely prevalent in this country. A public hearing shall be given before an order under this section takes effect.

Section 9 provides for suitable rules for carrying out the purposes of this act.

Section 10 provides penalties for violations of the provisions of this act. A common carrier proving that it did not knowingly violate this act shall not be deemed guilty.

Section 11 defines "person" as used in this act; also makes corporations and firms responsible for their employees' acts.

Section 12 provides for a Federal Horticultural Board consisting of five members, not more than two of whom shall be appointed from each of the Bureaus of Plant Industry, Entomology, and Forest Service.

Section 13 appropriates \$25,000 for carrying out the provisions of the act.

Section 14 makes the act effective on and after October 1, 1912.

The permit system simply furnishes the Secretary of Agriculture certain definite information about each shipment, which it is necessary to have in order to have the proper inspection made. The foreign certificate of inspection is required, not because it is of value now, but because this requirement will lead to closer attention by foreign inspectors to the health of plants certified by them and thus lead to a better class of stock being offered for entry. The actual inspection of imported stock is left entirely to the proper State officials, who are furnished full information concerning shipments of nursery stock coming to their States.

The most important feature of the bill is the quarantine power given against dangerous new diseases and insects, which may be enforced against any foreign country or locality or any State or locality within this country.

The Federal Horticultural Board, which administers the provisions of the act, has issued the following notice regarding white-pine blister rust:

NOTICE OF QUARANTINE NO. 1.

(Issued pursuant to sec. 7 of the Plant Quarantine Act.)

WHITE-PINE BLISTER RUST.

UNITED STATES DEPARTMENT OF AGRICULTURE,

OFFICE OF THE SECRETARY,

Washington, D. C., September 16, 1912.

The fact has been determined by the Acting Secretary of Agriculture that a tree disease known as White-Pine Blister Rust (*Peridermium strobi* Kleb.), new to and not heretofore widely prevalent or distributed within and throughout the United States, exists in the following countries, viz, Great Britain, France, Belgium, Holland, Denmark, Norway, Sweden, Russia, Germany, Austria, Switzerland, and Italy.

Now, therefore, I, Willet M. Hays, Acting Secretary of Agriculture, under authority conferred by section 7 of the act approved August 20, 1912, known as "the Plant Quarantine Act," do hereby declare that it is necessary, in order to prevent the introduction into the United States of the White-Pine Blister Rust, to forbid the importation into the United States from the hereinbefore-named countries of the following species and their horticultural varieties, viz, white pine (*Pinus strobus* L.), western white pine (*Pinus monticola* Dougl.), sugar pine (*Pinus lambertiana* Dougl.), and stone or cembrian pine (*Pinus cembra* L.).

Hereafter and until further notice, by virtue of said section 7 of the act of Congress approved August 20, 1912, the importation for all purposes of the species and their horticultural varieties from the countries named is prohibited.

Done at Washington this 16th day of September, 1912.

Witness my hand and the seal of the United States Department of Agriculture.

[SEAL.]

WILLET M. HAYS,

Acting Secretary of Agriculture.

Circular No. 41 of the Office of the Secretary of the United States Department of Agriculture, entitled "Rules and Regulations for Carrying Out the Plant Quarantine Act," gives the rules and regulations adopted for carrying out the provisions of the act.

It is known that since the passage of the Plant Quarantine Act shipments of some of these quarantined species of pine have been received in this country under false names. It should be remembered that the penalty for violating the act is a maximum fine of \$500 or imprisonment not exceeding one year.

[Cir. 129]

THE WORK OF THE UMATILLA EXPERIMENT FARM IN 1912.¹

By R. W. ALLEN, *Collaborator, Office of Western Irrigation Agriculture.*

INTRODUCTION.

The average annual rainfall on the Umatilla Project is only about 9 inches. The altitude averages 470 feet, and the growing season is relatively long. Much of the soil on the project is sandy and practically all of it is deficient in vegetable matter, so that it is easily moved by wind, and its water-holding capacity is not high. The size of the farm unit is limited to 40 acres. In 1912 the average irrigable area of the 295 farm units on the project was about 30 acres, and an average of only 16 acres per farm unit was actually irrigated.



FIG. 1.—View showing the buildings on the Umatilla Experiment Farm.

On account of the small size of these farms it is necessary that systems of intensive agriculture be established. The low altitude and long growing season are well suited to the production of certain truck crops and fruits and to dairy farming. One of the first requirements in successfully establishing crop production on the project is to supply the soil with organic matter, so as to reduce the damage by soil blowing and to increase the water-holding capacity. It is neces-

¹ Issued June 7, 1913.

The Umatilla Experiment Farm is located on the Umatilla Reclamation Project, about 2 miles north of Hermiston, Oreg. The farm contains 40 acres of land withdrawn from entry in 1908 by the Department of the Interior for use as an experiment farm. It is maintained by the Oregon Agricultural Experiment Station and is operated in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, under a cooperative agreement. Operations were begun in 1909. The buildings (see fig. 1) used were constructed by the United States Reclamation Service and by the Oregon Agricultural Experiment Station. The expenses of the farm are shared equally by the Oregon station and the Office of Western Irrigation Agriculture. The investigational work is under the immediate supervision of a farm superintendent, who is also a collaborator of the Bureau of Plant Industry.

sary also that crop varieties suited to the conditions on the project be found and that cultural methods suited to local conditions be determined.

Since its establishment in 1909 the Umatilla Experiment Farm (fig. 1) has been devoted to the investigation of these problems. The work of the farm is mainly horticultural and is at present confined chiefly to testing varieties of orchard fruits, small fruits, and truck crops and to investigating methods of producing these crops. All the experiments are under irrigation.

CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

Measurements of precipitation, evaporation, wind velocity, and temperature are made in cooperation with the Biophysical Laboratory of the Bureau of Plant Industry. A summary of these climatological observations in 1912 is given in Table I.

TABLE I.—*Summary of climatological observations at the Umatilla Experiment Farm in 1912.*

Character of data.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Precipitation.....inches..	2.22	0.67	0.49	0.61	1.25	0.97	0.05	1.18	0.10	0.29	0.54	0.13	8.50
Evaporation.....do.....				3.98	5.21	7.51	8.23	5.68	3.87	2.98	.78	.25	138.49
Wind velocity per hour, miles.....	2.5	4.0	3.3	2.5	3.1	5.3	4.4	3.8	2.5	3.5	1.7	4.3	3.4
Temperature:													
Maximum.....° F..	52	58	71	78	91	104	102	102	87	78	62	63	104
Minimum.....do.....	-18	16	15	26	35	43	48	41	32	23	20	12	-18
Mean.....do.....	29	40	41	52	61	69	72	69	59	48	42	35	51

¹ Evaporation for 9 months, April to December, inclusive.

The dates of the last spring frosts and first autumn frosts from 1909 to 1911, inclusive, were obtained from the local office of the Reclamation Service at Hermiston, about 2 miles from the experiment farm. In 1912 the observations were made at the farm. These data for the four years 1909 to 1912, inclusive, are given in Table II.

TABLE II.—*Killing frosts at or near Hermiston, Oreg., 1909 to 1912, inclusive.*

Years.	Last in spring.		First in autumn.		Frost-free period.
	Date.	Minimum temperature.	Date.	Minimum temperature.	
		° F.		° F.	Days.
1909.....	Apr. 21	27	Oct. 16	30	178
1910.....	Apr. 30	27	Oct. 15	31	168
1911.....	Apr. 20	31	Sept. 23	26	156
1912.....	Apr. 16	31	Oct. 6	31	173

CROP CONDITIONS.

The crop conditions on the Umatilla Project were only fairly satisfactory in 1912. Late spring frosts did some damage to the tender small fruits, particularly strawberries. A destructive windstorm on June 20 damaged all crops to some extent and seriously injured some of the truck crops.

In 1912 the total irrigable area of the farms on the project was 9,091 acres, included in 295 farm units. Of this an area of 4,600 acres was actually irrigated. Young orchards not yet in bearing occupied 1,175 acres, and green-manure crops and other miscellaneous crops which were not harvested occupied 207 acres, so that the total area of crops harvested was 3,218 acres. The acreage, yields, and farm values of the crops grown on the project in 1912 are stated in Table III. The figures were obtained from the United States Reclamation Service.

TABLE III.—*Acreage, yields, and farm values of crops grown on the Umatilla Project in 1912.*

Crop.	Area (acres).	Yield.				Per unit of yield.	Farm values.		
		Unit.	Total.	Per acre.			Total.	Per acre.	
				Aver- age.	Maxi- mum.			Aver- age.	Maxi- mum.
Alfalfa.....	2,442	Ton...	8,388	3.43	8	\$7.00	\$58,716	\$24.00	\$56.00
Clover.....	34	do...	36	1.06	6	7.00	252	7.42	42.00
Rye hay.....	626	do...	335	.54	2½	5.00	1,675	2.68	12.50
Corn fodder.....	38	do...	57	1.50	12	6.00	342	9.00	72.00
Berries.....	26	Pound	22,600	869	6,400	.11½	2,599	100.00	736.00
Grapes.....	52	do...	26,000	500	3,200	.04	1,040	20.00	128.00
Melons.....	18	do...	35,200	1,956	4,000	.05	1,760	97.80	200.00
Onions.....	4	Ton...	54	13.50	16	21.00	1,080	270.00	320.00
Potatoes.....	94	do...	553	5.90	10	15.00	8,295	88.40	150.00
Artichokes.....	6	do...	25	4.17	10	20.00	500	8.34	200.00
Garden.....	328	do...	48	.15	4	20.00	960	2.92	80.00
Less duplications.....	450								
Total or average.....	3,218						77,219	24.00	

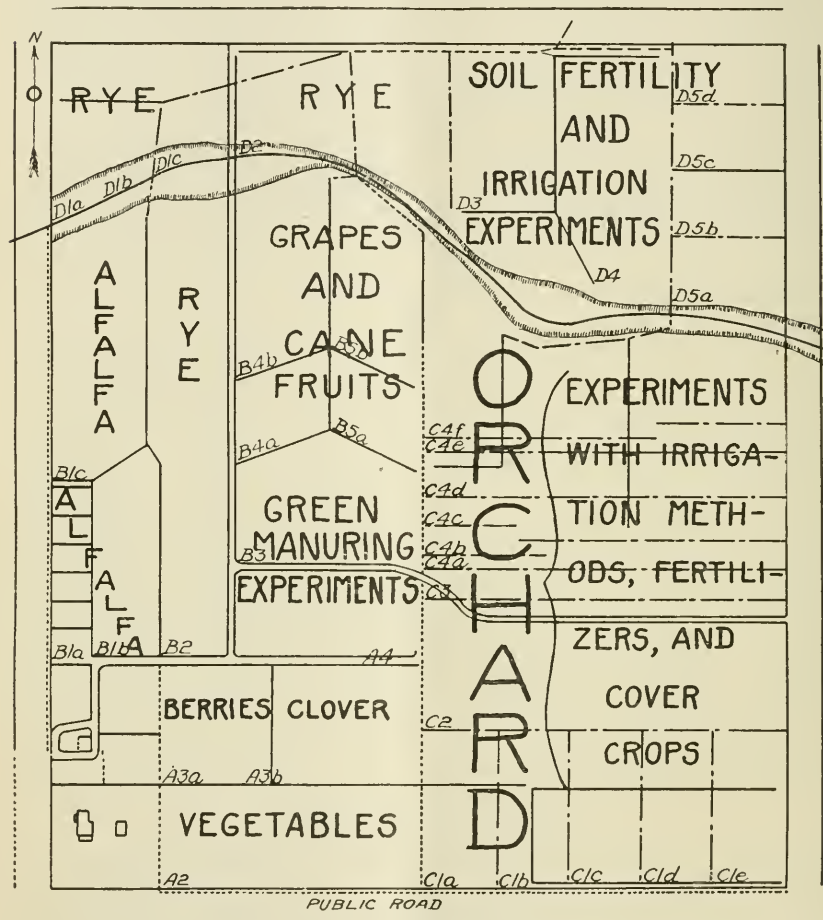
FIELD EXPERIMENTS.

The field experiments in progress at the experiment farm in 1912 had to do chiefly with the following: (1) The testing of fruit varieties and methods of their production; (2) the identification and testing of varieties of garden and truck crops; (3) experiments with methods of increasing the supply of organic matter in the soil, including tests of several green-manure crops; (4) variety tests of numerous hardy shrubs and trees suitable for ornamental purposes and as windbreaks; and (5) tests of different irrigation methods. The arrangement of the fields and the location of the experiments in 1912 are shown in figure 2. A brief description of these experiments

follows, together with a discussion of some of the more important results.

FRUIT VARIETIES.

The fruit variety tests include 11 different kinds of fruit, of which 327 different varieties are being grown. The number of individuals being tested in each variety varies from 2 of quinces, nectarines, and



UMATILLA EXPERIMENT FARM

FIG. 2.—Diagram of the Umatilla Experiment Farm, showing the arrangement of the fields and the location of the experiments in 1912.

apricots to 25 of strawberries. The total number of individuals in the fruit variety tests is 3,544. The names of the fruits and the number of varieties and individuals of each are given in Table IV.

TABLE IV.—*List of fruits in the variety tests at the Umatilla Experiment Farm in 1912.*

Kind of fruit.	Number of varieties.	Number of individuals in each variety.	Kind of fruit.	Number of varieties.	Number of individuals in each variety.
Apples.....	47	3	Cane fruits.....	5	12
Pears.....	14	3	Do.....	37	24
Quinces.....	7	2	Strawberries.....	75	25
Prunes and plums.....	22	3	Grapes.....	28	8
Cherries.....	25	3	Total.....	327	3,544
Nectarines and apricots.....	17	2			
Peaches.....	50	3			

Following are the varietal names of the fruits listed in Table IV:

Apples.—Alexander, Red Astrachan, Oldenburg (*Duchess of Oldenburg, Duchess*), Goodwin, Gravenstein, Tompkins King (*Tompkins County King*), Maiden Blush, Fameuse (*Snow*), Yellow Transparent, Akin (*Aiken, Akin Red*), Arkansas Black, Babbitt, Baldwin, Yellow Bellflower, Ben Davis, Bennett, Delicious, Gano, Grimes (*Grimes' Golden*), Jonathan, Lady, Lawver (*Delaware Red Winter*), McIntosh, Arkansas (*Mammoth Black Twig*), Yellow Newtown, Northern Spy, Oregon Winter (*Oregon Red Winter*), Orenco, Ortley, Red Cheek, Rome Beauty, Esopus (*Spitzenberg*), Stayman Winesap, Wagener, Wealthy, White Pearmain (*White Winter Pearmain*), Willow (*Willow Twig*), Winesap, Banana (*Winter Banana*), Winterstein, York Imperial.

Crab apples.—Hyslop, Martha, Red (*Red Siberian*), Yellow Siberian, Transcendent, Whitney (*Whitney's No. 20*).

Pears.—Bartlett, Anjou, Bosc, Clairgeau, Clapp, Comice, Flemish (*Flenish Beauty*), Howell, Idaho, Madeleine, Rossney, Seckel, Winter Bartlett, Winter Nelis.

Quinces.—Angers, Apple, Bourgeat, Champion, Pineapple, Rea (*Rea's Mammoth*), Smyrna.

Prunes.—German, Hungarian, Italian, Agen (*Petite*), Pond, Sergeant (*Robe de Sergeant*), Sugar, Tragedy, Golden Drop (*Coe's Golden Drop, Silver*).

Plums.—Abundance, Bradshaw, Burbank, Lombard, Maynard, Peach, Satsuma, Sultan, Wildgoose, Yellow Egg, Wickson, Gold, Wyant, Surprise, Terry.

Cherries.—Bing, Centennial, Chapman, Deacon, Early Purple, Elton, Wood (*Governor Wood*), Lambert, Lewelling, Montmorency Ordinaire, Windsor, Napoleon (*Royal Ann*), Spanish (*Yellow Spanish*), Baldwin, Richmond (*Early Richmond*), English Morello (*Wragg*), Kentish, Late Duke, Lutovka, May Duke, Large Montmorency, Olivet, Ostheim, Vladimir.

Nectarines.—Boston, Humboldt, New White, Stanwick.

Apricots.—Alexander, Alabis, Black, Blenheim, Hemskirke, Budd (*J. L. Budd*), Moorpark, Newcastle (*Newcastle Early*), Peach, Royal, Routier (*Routier's Peach*), Smyrna, Tilton.

Peaches.—Dewey (*Admiral Dewey*), Alexander, Arp (*Arp Beauty*), Australian Saucer, Bilyeu, Briggs (*Briggs Red May*), Champion, Columbia, Early Crawford, Late Crawford, Crosby, Elberta, Fitzgerald, Foster, George Late (*George's Late Cling*), Globe, Greensboro, Hale Early, Heath (*Heath Cling*), Imperial Early, Sims Cling, Levy (*Levy's Late*), Lovell, McDevitt (*McDevitt's Cling*), McKevitt, Morris (*Morris White*), Mountain Rose, Muir, Opulent, Perfection, Persian Cling, Phillips (*Phillips's Cling*), Picquet (*Picquet's Late*), Runyon (*Runyon's Orange*), Salway, Sellers, Levis Cling, Sneed, Strawberry, Susquehanna, Triumph, Tuskena (*Tuscan Tuscan Cling*), Van Buren (*Van Buren Dwarf*), Wheatland, Smock, Webers Prize, St. John (*Yellow St. John*), Belle (*Belle of Georgia*), Carman, Chinese Cling.

Grapes.—Black Hamburg, Black Prince, Flame Tokay, Mission, Muscatel, Rose of Peru, Agawam, Brighton, Catawba, Campbell, (*Campbell Early*), Delaware, Eaton, Early Ohio, Winchell (*Green Mountain*), Isabella, Lindley, McPike, Diamond (*Moore's Diamond*), Moyer, Niagara, Pocklington, Woodruff (*Woodruff's Red*), Wyoming. In commercial planting four additional varieties are under trial: Concord, Moore (*Moore's Early*), Salem, and Worden.

Currants.—Champion (*Black Champion*).¹ Naples (*Black Naples*).¹ Cherry, Fay (*Fay's Prolific*), Perfection, White Grape, Lee (*Lee's Prolific*).¹

Gooseberries.—Downing, Industry, Josselyn, Oregon (*Oregon Champion*), Pearl, Smith (*Smith's Improved*), Victoria, Houghton.

¹ Black sort.

Raspberries.—Brandywine, Cardinal, Cumberland, Cuthbert, Loudon, Miller, Columbian, Gregg, Haymaker, Kansas, Munger, Shaffer (*Shaffer's Colossal*), Johnson (*Johnson's Sweet*), Atlas.

Dewberries and blackberries.—Mayes (*Astin Improved*), Gardenia, Lucretia, Premo, Early Harvest, Eldorado, Erie, Kittatinny, Lawton, Mercereau, Rathbun, Snyder, Wilson (*Wilson's Early*), Ward.

Miscellaneous brambles.—Phenomenal, Loganberry, Himalaya, Mammoth, Evergreen, Japanese wineberry.

Strawberries.—Arizona (*Arizona Everbearing*), Beedler, Bismarck, Brandywine, Buchach, Cardinal, Clark (*Clark's Seedling*), Climax, Dornan, Glen Mary, Gold Dollar, Gandy, Hopkins (*Hopkins's Choice*), Hummer, Klondike, Thompson (*Lady Thompson*), Magoon, Mark Hanna, Michel (*Michel's Early*), Midnight, Miller, Nick Ohmer, New York, Oregon (*Oregon Ironclad*), Pride (*Pride of Michigan*), Sample, Dunlap (*Senator Dunlap*), 16 to 1, Splendid, Tennessee (*Tennessee Prolific*), Texas, Thompson No. 2, Woolverton, William Belt, Auto, Autumn (*Autumn Bell*), Bederwood, Corsican, Fendall, Goodluck, Kansas, Marshall, Oswego, Parker Earle, Paul Jones, Pocomoke, Sharpless, St. Lewis, August Luther, Chesapeake, Clyde, Ozark (*Early Ozark*), Excelsior, Gibson, Haverland, Washington (*Lady Washington*), Longfellow, Morse, New Oregon, Virginia, Warfield, Acme, Aroma, Buster, Crescent, Enormous, Heritage, Highland, Lovett, Parson (*Parson's Beauty*), Stevens (*Stevens's Late Champion*), Pride (*Downing's Pride*), South Dakota No. 1.

Separate areas of grapes and pears of sufficient size to give figures on yields per acre and similar data are being grown. Included in the experiments on methods of building up the soil are 4 acres of apples and $1\frac{3}{4}$ acres of peaches, which will be used to determine yields.

Apples have proved to be the most hardy tree fruit under trial, there having been less loss of trees and a better growth throughout. This is particularly true on the coarse sandy soils of the district. In locations where there is seepage or where silt-loam soils prevail peaches, pears, and cherries make a rapid and strong growth. Pear trees frequently act peculiarly the first year. Many of them remain green and appear fresh, but do not leaf out. Some of these start the second year and occasionally do better than those that started into growth the first season. The reason for this suspension of growth has not been determined. The Bartlett pear appears to be the hardiest variety in the experiment. Observations on the project indicate that pears are doing much better on the heavy soils than on the sandy ones.

Prunes and plums do not succeed as well as apples on the sandy soils. Such varieties as the Peach, Maynard, Sergeant, and Abundance make a rapid growth. Italian, Pond, and Golden Drop (*Silver*) prunes do fairly well when once established on light soils, but heavy losses are frequent.

Conditions on the project appear to be less favorable to the growth of cherries than to that of any other tree fruit tested. The sour cherries are much more hardy than the sweet varieties. This fruit will probably sustain some loss from frost on account of its comparatively early blossoming.

Peaches do well on silt soils and when once established make a strong growth on the sand. Observations throughout the district show that peach buds are more subject to winter freezing on the light than on the heavier soils, and the early blossoming of this fruit ren-

ders it liable to occasional loss from spring frost. Peaches are not as dependable a crop as apples and grapes, which blossom later in the season.

Desirability of small nursery stock.—Large or old trees in which there is an excessive quantity of wood frequently dry out, thus preventing proper growth and frequently causing heavy losses in newly planted orchards. As a check upon the observations made under field conditions a small experiment was carried out at the experiment farm in 1912 in which pear and cherry trees were used. These fruits have been the most difficult to get started. One-year-old trees, varying in size from the largest obtainable down to those less than 2 feet in height, were planted and cut off at varying distances from the ground. The experiment has shown conclusively that large trees are not desirable on account of the wood drying out, that small and medium-sized trees cut at 18 inches make a strong growth and are susceptible of being properly trained, and that medium-sized trees cut down to 4 or 6 inches in height have made the best showing. This treatment will be found advantageous in getting sweet cherries and pear trees started where the soils are sandy. Trees that were not cut off sustained heavy loss and the surviving ones made but little growth.

Sun scald.—The effect of sun scald, which has caused the loss of a large number of trees throughout the district, can be much reduced by shading the trunk of the tree at the ground with straw or shingles. Wrapping with wood veneer is not advisable, because of the fact that it frequently prevents the proper distribution of branches on the body of the tree and involves more outlay than the use of straw or other inexpensive materials. A sod of rye or small bunches of straw placed on the south side of the trees near the base will practically insure them from being injured by sun scald. Trees in need of water are more susceptible to sun scald than those which have sufficient moisture.

Grapes.—*Vinifera*, or European, grapes freeze down frequently if not covered during the winter. The best covering material to use is the vineyard soil, which can be plowed or shoveled over the vines after they have been pruned at the beginning of cold weather. *Sultanina* (*Thompson Seedless*) is the most hardy of the varieties so far grown in the vicinity. The *Flame Tokay* makes a strong growth and produces an abundance of fruit, which is slow to mature unless the vines are pruned to prevent excessive shading. The *Alexandria* and *Black Hamburg* do well.

The American varieties are better adapted to this locality than the *Viniferas*. They are hardy, withstanding the most severe weather, and yield abundant crops of very sweet fruit. The *Worden* appears to be hardier than the *Concord* on sandy soils. These two varieties are preferable on account of their superior market value, but they can be supplemented by the *Salem*, *Niagara*, and *Moore*, all of which do well. The proposed establishment of grape-juice factories at *Kennewick*, *Wash.*, and other places in the Northwest increases the possibility of greater demand for *Concords* and *Wordens*.

Crown-gall is prevalent throughout the district on *Vinifera* grapes. It has also been noted to some extent on cane fruits, prunes, peaches, and apples. Care should be taken in planting not to use any infected nursery stock. Where this trouble is known to exist it is important to prevent its spread to other orchards and vineyards. Because of the present general infection of *Vinifera* grapes it seems advisable that their culture should be discouraged.

Cane fruits.—*Blackberries*, *raspberries*, *dewberries*, and *gooseberries* thrive on the fine soils; and on sandy locations *loganberries*, *Lucretia* and *Premo dewberries*, and *Evergreen*, *Lawton*, *Mammoth*, and *Himalaya blackberries* grow fairly well. *Loganberries* require covering during winter to prevent the freezing of the canes.

Strawberries.—*Strawberries* yield abundantly on silt soils, but as a rule they do not pay on sandy soil unless it has been well fertilized. The *Clark* is preferable for com-

mercial growing on account of its superior shipping qualities. The Gold Dollar and Magoon are being used to some extent. The Miller and Arizona are good for home use, but are too soft to ship successfully. The hill system of culture is preferable because it facilitates the work of keeping the bed free from weeds and the fruit is larger and more easily gathered.

GARDEN AND TRUCK CROPS.

The work of identifying and testing varieties of garden and truck crops is conducted in cooperation with the Office of Horticultural Investigations of the Bureau of Plant Industry. In this work special emphasis is placed upon the determination of the adaptability of the varieties to local conditions and market requirements. During the three years 1910 to 1912, 67 varieties have been tested. In 1912 there were 37 varieties under test, including those which appeared to be the most promising in previous years and some new varieties. Table IV gives the names of the crops included in these tests, the number of varieties of each on trial in 1912, and the total number of varieties tested to date.

TABLE V.—*Garden and truck crops under test at the Umatilla Experiment Farm.*

Kind of crop.	Number of varieties tested.		Kind of crop.	Number of varieties tested.	
	In 1912.	To date.		In 1912.	To date.
Asparagus.....	2	2	Peanuts.....	3	2
Rhubarb.....	5	5	Beans.....		4
Watermelons.....	8	14	Corn.....	3	8
Cantaloupes.....	3	4	Potatoes.....	11	18
Eggplant.....	2	4			
Peppers.....		6	Total.....	37	67

Nineteen varieties of tomatoes have been tried out with a view to producing a variety with pronounced immunity from western tomato blight, for a foundation upon which to carry out selection and breeding experiments. Various methods of culture are also being tried to study their effect upon the growth of this plant.

Asparagus.—Asparagus does well on the project and is growing in popularity as a commercial crop. The plants must not be crowded, and the beds should be covered with manure or straw as a mulch during the winter and to protect the young shoots in the early spring. The Palmetto is the best variety so far tested, because of its extreme hardness.

Melons.—Watermelons of good quality are being grown, but have not been marketed to advantage, on account of the small quantity produced. There is a demand for this product in carload lots, and as it can be cheaply grown the industry should be more extensively developed. The Kleckley Sweet (*Monte Cristo*) is not the heaviest producer of the 14 varieties tried, but it yields the largest percentage of salable melons.

Cantaloupes do not thrive on sandy raw land, but do well on highly fertilized sand and on silt soils. The Emerald Gem and Rocky Ford varieties are preferable, as determined by observations in the district.

Potatoes.—The production of early potatoes is a promising industry on the project, but it sustained a severe check in 1912, when the crop could not be sold to advantage.

Prices are usually good, however, and the output might well be increased. For early production the Early Ohio and Irish Cobbler are the best varieties so far determined. Sommers' Extra-Early, which had been grown but one season, promises to have superior value.

Eggplant.—Eggplant is a promising crop, as it produces heavy yields of fruit of excellent quality. Since the plants are slow to mature, they need to be started in a hotbed. The New York Improved and Black Beauty varieties are preferable. Markets are not yet established for large quantities of eggplant, but from its increasing popularity there appears to be a good future for it.

Onions.—The moist, subirrigated lands, of which there is a rather large area on the project, are adapted to the production of onions. Early spring seeding is necessary to insure a good stand and to get the crop well grown before warm weather comes on. The Prizetaker yields large crops of medium-sized onions, which are preferred by dealers. The Yellow Globe Danvers is a good variety, but not so productive as the Prizetaker. Onions should be sold in carload lots, so as to diminish the cost of marketing.

SOIL IMPROVEMENT.

The virgin soils on the Umatilla project are very deficient in nitrogen and humus. The mineral plant foods are more abundant. The quantities of nitrogen, potash, phosphoric acid, and lime found in two samples, one of sandy soil and one of silt loam, are stated in Table VI.

TABLE VI.—*Analyses of samples of soil on the Umatilla project.*

Constituent.	Sandy soil.		Silt loam, surface.
	Surface.	Subsoil.	
Nitrogen.....per cent..	0.0233	0.0017	0.03
Acid-soluble potash.....do....	.2680	.3600	.39
Acid-soluble phosphoric acid.....do....	.2400	.2650	.19
Acid-soluble lime.....do....	1.1900	.8600	.33

To determine the quickest and most economical method of increasing the productivity of these soils the following experiments have been in progress since 1910:

Experiment No. 1 consists of five plats, all planted to apple trees. Plat No. 1 has a winter cover crop of vetch and one garden crop (fig. 3) grown on it each year. Plat No. 2 has a winter cover crop of vetch and some leguminous summer crop (fig. 4) grown on it and incorporated in the soil each year. Plat No. 3 has rye grown on it each winter and is given an occasional light application of manure. Plat No. 4 has alfalfa in the spaces and strips of cultivated land along the tree rows. Plat No. 5 has a solid stand of alfalfa among the trees.

Experiment No. 2 consists of three tests, which are designed to show, if possible, whether it is best to start an orchard in the virgin soil with no special fertilizer, to start it in this way and enrich the soil with frequent applications of manure and commercial fertilizers, or to start trees on 2-year-old alfalfa sod. Two and one-quarter acres of land are being used for this experiment and four varieties of peach trees are planted in rows running across the plats.

Experiment No. 3 is designed to determine what changes can be brought about in the soil by the repeated use of barnyard manure and commercial fertilizers. Different crops are grown on the entire area each year. Some of these are leguminous crops,

while others are vegetables of some kind. The fertilizers used are nitrate of soda, potash, phosphoric acid, lime, blood meal, tankage, and stable manure. Chemical tests were made before the fertilizers were applied, to determine the condition of the virgin soil, and will be repeated at intervals of two years to determine the rate and nature of any changes which may occur.



FIG. 3.—View in field used for experiments in soil building. Three crops of winter vetch have been plowed under on this field, and the soil has been markedly improved.

A fourth experiment, which seeks to determine the value of different leguminous plants as cover crops and nitrogen accumulators for the local orchard soils, has been in progress since 1910. This test includes 10 different crops, as follows: Sainfoin, or esparsette (*Onobrychis sativa*), red clover, mammoth red clover, crimson clover, sweet clover, alfalfa, Canada field peas, cowpeas, hairy vetch (*Vicia villosa*), and spring vetch (*V. sativa*). In addition to the work being done with these legumes at the



FIG. 4.—Peanuts and milo, following a winter cover crop of vetch, grown between the rows of young orchard trees.

experiment farm, cooperative experiments with some of the more promising crops are in progress with farmers on the Umatilla and Inland irrigation projects, to determine the value of the crops on the different types of soil.

Some very encouraging results have been derived from these experiments. Hairy vetch sown in August or September makes a

rapid early growth the next spring, and can be turned under about May 1. The succulent green material when incorporated in the soil adds a large amount of fertility and greatly increases the water-holding capacity of the soil. A decided improvement can be seen in land where three crops of vetch have been grown and plowed under. The present high price of seed almost prohibits the use of this crop, but it can be effectively used in orchards by allowing a strip to go to seed between the tree rows each year. Spring vetch winterkills, and can not be used for fall seeding.

Red clover and sweet clover (*Melilotus alba*) are valuable cover crops, but are more difficult to grow than vetch. When they are sown in early spring a fair crop of forage can be turned under the following November, and when planted in August a good crop can be grown to plow in the following May or June.

Alfalfa is not desirable as a crop to grow in orchards, on account of the difficulty of its eradication.

Canada field peas when sown in early spring make a rapid growth, and can be plowed under to advantage about June 1. On account of its rapid growth this is the best spring-planted green-manure crop that has been tried.

It is good practice to sow all available land to clover or vetch early in the fall with a view to plowing under a crop of green manure the following spring. The seeding can be done on land producing garden crops, and in orchards at the time of the last cultivation.

TREES AND SHRUBS.

A test, including 34 varieties of 20 hardy shrubs, is being conducted to determine which shrubs are best suited for use in beautifying home grounds in the locality. Some attention is given to trees for shade and for windbreak purposes, and 39 different kinds of trees are being tested in nursery rows in cooperation with the Forest Service. About one-half of an acre is devoted to this nursery work.

For windbreaks, where space can be given for only one row of trees, the black locust and Carolina poplar are desirable. The trees should be planted from 5 to 7 feet apart. If liberally irrigated they will afford considerable protection in three years. The Lombardy poplar may also be used as a windbreak. It should be planted in double rows, on account of its slender habit of growth. These trees should be placed where the roots will not be disturbed, or suckering will result. European larch, Scotch pine, western yellow pine, and Russian oleaster can be expected to grow if good care is given them. They are ornamental, and also effective as windbreaks. Tamarisk, red cedar, privet, and hardy hydrangeas can be successfully grown for ornamental purposes.

IRRIGATION METHODS.

A few tests of irrigation methods of a simple nature have been conducted. These have consisted principally in determining the effects of using moderate and excessive quantities of irrigation water on young apple trees, comparing the quantity of water required in orchards where alfalfa is grown between the trees with that required where no such crop is grown, and making soil-moisture determinations on a few plats which are cultivated and irrigated in different ways. The moisture determinations are made in cooperation with the Biophysical Laboratory, Bureau of Plant Industry. Some observations have been made of the different irrigation methods practiced by the farmers on the project.

To prevent excessive losses from running water in small ditches and to eliminate the undesirable growth of weeds along the ditch banks, concrete pipe lines have been laid on the experiment farm to carry the water to distributing flumes. Concrete diversion and measuring boxes equipped with specially designed weir gates have been installed to facilitate careful measurement and prompt delivery of water to the respective fields. The initial cost of concrete-lined ditches and concrete pipe lines is from 50 to 100 per cent more than that of wooden flumes, but on account of their greater durability and freedom from leakage they are in the end much more economical.

Irrigation methods best suited to the light sandy and silt loam soils have been receiving special attention. Frequent light applications have been found to be more effective and more economical of water than are less frequent heavy applications. The furrow system of applying water is by far the best adapted to the rough topography and porous soil of the region. Relatively short furrows should be used, as heavy losses result from deep percolation where the water is kept running for a time over porous soil in an attempt to run the water long distances.

FARM BUILDINGS.

During 1912 a machine shed and small workshop building was added to the group of farm buildings erected on the farm. The structure is 16 by 40 feet, which gives sufficient room for the machinery and for a small workshop and seed room. A concrete hotbed, 6 by 18 feet, has been constructed to replace a wooden frame which had fallen to pieces in three years from decay.

EXTENSION WORK.

Some educational work is being done from time to time in the way of conducting pruning demonstrations and by giving lectures on various agricultural topics at public meetings. Frequent trips are made to different farms to inspect the crop and soil conditions with which the farmers are confronted and to assist them in their farm operations.

[Cir. 129]

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1913.

BUREAU OF PLANT INDUSTRY.

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Assistant Chief of Bureau, L. C. CORBETT.

Editor, J. E. ROCKWELL.

Chief Clerk, JAMES E. JONES.

[Cir. 130.]

COTTON PROBLEMS IN LOUISIANA.¹

By O. F. COOK, *Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.*

INTRODUCTION.

Louisiana must be considered as a State adapted to raising long-staple cotton. Short staples can also be grown, but there are special conditions that favor the production of long staples. The planting of early-maturing short-staple cottons in Louisiana was advised in the first years of the boll-weevil invasion as a means of avoiding acute distress from complete loss of crops, but this was because of the late-maturing habits of the long-staple varieties, which rendered them very susceptible to weevil injury. Earlier long-staple varieties are now available, and it is believed that these offer the best prospect of maintaining a permanent cotton industry in Louisiana.

Whether long-staple cotton can take the place of sugar cane on any of the Louisiana lands and how far such a substitution may be expected to go are questions of present interest, but even outside the sugar districts it is important to have more definite knowledge of the possibilities of improvement. The presence of the boll weevil introduces a new element of uncertainty and requires many readjustments that are not yet complete. New varieties and improved cultural methods have been developed in recent years by the Department of Agriculture and are likely to be useful in Louisiana, but they have still to be tested and adapted to the local conditions. There are problems of other kinds that remain to be solved. The selling of the cotton must be considered, as well as the raising of it. The substitution of short fiber is now a more serious menace to the long-staple industry than the boll weevil.

Some of the factors that affect the cotton industry are of a general nature and some are peculiar to Louisiana and adjacent districts. To meet special conditions special measures may be required, and some of these needs are already apparent. Thus, the need of community action is especially great in the Louisiana cotton industry, for reasons that are easy to see when the local conditions are con-

sidered. The moist climate and luxuriant growth of the plants increase the danger of weevil injury. Measures of protection, if they are to be at all effective, must be enforced by the concerted action of whole communities, and community agreements are also necessary in order to maintain the selection and preserve the purity of superior types of long-staple cotton. Finally, there is special need with long-staple cottons that commercial quantities of uniform high-grade fiber be produced in each community in order to market the crop to the best advantage. The individual farmer working alone is usually unable to secure more than a small part of the advantage that could be obtained if whole communities of farmers would unite in measures of improvement.¹

INCREASING COST OF LABOR.

The higher prices that have ruled in the cotton market in recent years do not mean that there has been a corresponding increase in the profits of large farms or plantations. The cotton crop still has to be picked by hand. Hopes of cotton-picking machines are not yet realized. The scarcity and higher cost of farm labor in the South is one of the general factors of cotton production that has changed rapidly in the last few years. The cost of picking has almost doubled in five years in some parts of Texas, and many laborers have been attracted from Louisiana. The rapid increase of city and town populations in the South has also drawn heavily, and especially upon the more intelligent and efficient part of the laboring population of the farming districts, for the towns afford more regular employment as well as higher wages.

With some of the laboring population increased wages mean a still further decline in efficiency, because a living is assured by fewer days of work. Instead of working four or five days in a week they may "get along" by working only two or three days.

The breaking up of large estates for sale or rent to small farmers is another factor in reducing the supply of labor available for the large planter, for the small farmers can live from their own land and are no longer in the market as general laborers. It is useless for large landowners to plant cotton unless pickers can be had when the harvest season arrives. Miscalculations on this point occasion losses of millions of dollars every year.

Thus, we have in the labor conditions alone a reason why it is becoming more difficult to maintain cotton production by hired labor on a large scale, or the plantation system. The fact that the labor demands of the cotton crop are not distributed regularly through the season means that farming on the basis of cotton alone is uneconomic

¹ Cook, O. F. Cotton improvement on a community basis. U. S. Department of Agriculture, Yearbook, 1911, p. 397-410, 1912.

from the standpoint of labor supply, to say nothing of other disadvantages of a one-crop system. In other words, cotton culture is likely to be more profitable as a part of a system of mixed farming. But this tendency to decentralized production must carry with it a larger extent of community cooperation, for reasons already intimated.

DETERIORATION OF UPLAND LONG-STAPLE COTTON.

One of the chief objects to be gained through the organized cooperation of cotton growers is to improve and maintain the quality of the crop. Even before the arrival of the boll weevil in the long-staple districts the manufacturers had begun to complain of a serious decline in the quality of the cotton that was being produced in Louisiana and Mississippi. The complaints were on the grounds that the cotton was sent to market in worse condition and that the fiber was more uneven. It is easy to see that both of these results would follow naturally from changes that were taking place in the long-staple industry. Labor was becoming more careless because of less effective control, and the old system of separate plantation gins was being abandoned because of the greater expense in comparison with the modern power gins.

The result of bringing together at a public gin all the cotton of a neighborhood is that the varieties become mixed, so that uniform fiber is no longer produced. The superior stocks that were formerly maintained on some of the plantations became contaminated, and it became more and more difficult to secure supplies of good seed. The tendency of the old system had been to preserve the beneficial effects of selection, such as any careful planter might practice, and extend them over the community, because the crop of each plantation was handled separately and the seed that might be sold by such a planter would also be handled separately on other plantations. But the system of public gins has the opposite effect of making it very difficult to maintain stocks of pure seed. And yet supplies of pure seed are a fundamental necessity if a long-staple industry is to be maintained.

The commercial and industrial value of long-staple fiber depends very largely on uniformity, for lack of this quality greatly increases the cost of manufacture. The short fibers have to be sorted out by elaborate mechanical processes. If the buyer detects the presence of short cotton he will pay only short-cotton prices for the whole bale. Indeed, it is often difficult to dispose of mixed bales, even at short-cotton prices.

The problem of preserving the uniformity of superior varieties of cotton by continued selection as a means of securing large yields and maintaining the quality of the fiber has received special attention in

recent years. Improved methods of selection, easier to apply and at the same time more effective, have been developed.¹

Selection of seed should be considered as a regular part of the farm operations with cotton. Every farmer should either select his own seed or buy it from a more careful neighbor. Neglect of selection is responsible for an enormous annual loss to the American cotton industry. A hundred million dollars would be a small estimate of this factor of agricultural inefficiency.

BEHAVIOR OF THE COTTON PLANT UNDER LOUISIANA CONDITIONS.

No other part of the cotton belt has produced Upland long-staple cotton of such high quality as the lower Mississippi Valley, in the States of Louisiana and Mississippi. Though excellent long-staple cotton can be grown in other States it is still doubtful whether any could compete in the production of fiber of the highest quality if the Louisiana and Mississippi planters were to take full advantage of the favorable natural conditions. In order to secure fiber of the greatest length and strength it is necessary that the plants have an adequate and continuously available supply of moisture, and this is afforded by rich alluvial lands like those of the Delta region, which has long been famous as the center of long-staple production.

Though the rich soil and abundant moisture of Louisiana are factors that favor the production of long-staple cotton, they also have the disadvantage of inducing too great luxuriance of vegetative development. When cotton plants grow too rapidly in the earlier stages they produce larger numbers of vegetative branches, each of which has the same possibilities of development as the main stalk. The result is a large, bushy, slow-fruited plant. The development of the fruiting branches is delayed because of the production of vegetative branches. Even when the plants begin to flower early in the season they may not produce an early crop, for the first of the fruiting branches are borne at the base of the main stalk, where they may be surrounded and overshadowed by the vegetative branches, so that the early buds are often blasted or the bolls fail to reach normal maturity.

The need of restricting the growth of the plants in the early stages of development has been recognized in Louisiana in the practice of deep cultivation, which has the effect of root pruning and is used as a means of inducing earlier fruiting. But a still more effective means

¹ Cook, O. F. Local adjustment of cotton varieties. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 159, 75 p., 1909.

——— Cotton selection on the farm by the characters of the stalks, leaves, and bolls. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 66, 23 p., 1910.

——— Cotton improvement under weevil conditions. U. S. Department of Agriculture, Farmers' Bulletin 501, 22 p., 1912.

of controlling the behavior of the plants has been found. The development of vegetative branches can be avoided by leaving the plants closer together during the early stages of growth; that is, by allowing the plants to grow larger before they are thinned and then leaving them closer together in the rows than has been customary.¹

To bring the plants to early fruiting by controlling the formation of branches seems to have distinct advantages over root pruning by deep cultivation, for controlling the branches does not involve any sudden checking of the growth of the plants, by which time may be lost in the development of the crop. There is also the danger that severe root pruning, if carried into the fruiting period, may cause the shedding of the flower buds and thus delay the crop in another way. The effect of the two systems is the same in the general sense that the individual plants do not grow as large as when no restrictions are imposed, but with the new system this limitation of the size of the individual plant is made good by leaving larger numbers of plants in the rows, though at the same time avoiding the injurious effects that would come from crowding if the vegetative branches were not suppressed. Nevertheless, the two methods of restricting growth can be readily combined if this should prove necessary under the extreme conditions found in Louisiana.

Another feature of the new system that may be of special value in Louisiana is that it may carry with it the possibility of securing an additional advantage from topping the plants as a further means of hastening the development of the crop. Under the usual system that allows the plants to develop vegetative branches topping often fails completely of its desired effect, or may even be injurious, since cutting off the main stalk may only stimulate the development of the vegetative branches. But with the vegetative branches suppressed the topping of the main stalk toward the end of the season may become a useful measure. These are some of the questions that require further experimental study.

It is still too early for any expression of opinion regarding the advantage to be gained from the new system under Louisiana conditions, but the results that have been secured in California and Texas seem to leave no doubt of the possibility of suppressing the vegetative branches and thus changing the habits of growth in the direction of earlier fruiting. With the vegetative branches out of the way the fruiting branches have better exposure to the sun and attain a better development. The plants are more upright, and the space between the rows is not filled by projecting vegetative branches.

¹ Cook, O. F. A new system of cotton culture. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 115, p. 15-22, 1913.

——— Abortion of fruiting branches in cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 118, p. 11-16, 1913.

This facilitates late cultivation and increases the chances of drying out the fallen buds, or "squares," and thus killing the weevil larvæ that the squares contain.

RELATION OF LOUISIANA CONDITIONS TO BOLL-WEEVIL INJURY.

Conditions that induce excessive growth and late fruiting of the cotton represent a maximum of exposure to weevil injury. The early flower buds enable the weevils to begin breeding, and the large bushy plants protect the larvæ in the fallen squares from the heat and dryness that might otherwise destroy many of them. By the time that the large plants have reached the stage of heavy fruiting the weevils are likely to have become so numerous that all of the buds are destroyed and no more bolls can be set.

That the boll weevil would be likely to drive the old late-maturing varieties of long-staple cotton out of cultivation was foreseen before Louisiana was invaded, and it was on this account that the development of earlier long-staple varieties was undertaken by the Department of Agriculture about a decade ago. This interval of time has proved sufficient for the development of improved types of long-staple cotton and improved methods of long-staple production.

Another reason why the weevil danger appears more serious in Louisiana is because much of the country is wooded and thus affords unusual facilities for the hibernation of the insects, especially in timber overhung with Spanish moss. The prolonged periods of drought that often decimate and sometimes almost exterminate the weevil population over wide regions in Texas are less likely to give respites from weevil danger in Louisiana.¹

The conclusion to be drawn from these facts is not that cotton culture has become impossible in Louisiana, for good crops are often raised in the presence of the boll weevil, but that all the precautions for avoiding weevil injury will need to be observed even more carefully and efficiently in Louisiana than in other parts of the cotton belt.

MEASURES OF PROTECTION AGAINST THE BOLL WEEVIL.

Many ways of avoiding boll-weevil injury have been suggested, but to secure a maximum of protection several different measures need to be combined. Communities should unite upon the same variety of cotton, plant it at the same time in the spring, use improved cultural methods to shorten the crop season, and clear the fields early in order to deprive the weevils of food and breeding places in the late fall and early spring months.

In communities that could agree to begin the planting of their cotton on the same date very early planting would not be necessary,

¹ Cook, O. F. Relation of drought to weevil resistance in cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 220, 30 p., 1911.

and this would be an advantage for the community as a whole, for the weevils would have less opportunity to breed than if some of the cotton were planted very early; and, on the other hand, there would be less danger of injury to the crop from periods of cold or wet weather or from spring floods. Where spring floods are of frequent occurrence and likely to interfere with early planting it is especially important to learn the extent to which weevil injury may be avoided by other means, such as the control of the habits of branching.

If the necessary precautions were observed, the power of the weevil to inflict serious injury or destroy the crop would be limited to the unfavorable seasons that might not permit the cotton to set a full crop of bolls before the weevils could become destructively numerous. That further advantages may be gained, at least in particular cases, by picking up the fallen squares or by the poisoning of overwintered weevils on the young plants in the spring is not improbable, but it is certainly a mistake to suppose that these measures can be relied upon and the others neglected.¹

One of the chief obstacles in the way of a proper appreciation and application of methods of weevil control is likely to come from the fact that there will be occasional good seasons, with enough dry weather in the early part of the growing season to hold the weevils in check, even in districts where no precautions have been taken. Fortunately, or perhaps unfortunately, seasons of this kind have already occurred since the weevils reached Louisiana, and some of the planters have been encouraged to believe that they could go ahead with cotton raising on the same basis as before the weevils arrived. Thus, from the standpoint of permanent improvement of the industry, favorable seasons may be more dangerous than those that show the advantage of adopting improved methods.

Many people find consolation in the idea that the weevil will pass on in a few years or that some new enemy or other restrictive agency will intervene to mitigate its ravages. But such reflections should not be advanced as reasons for neglecting to adopt better varieties and methods of production, for these improvements are of value quite apart from the problem of weevil resistance, as shown by experiments in California and Virginia, where no weevils exist. The difference is that in the presence of the boll weevil greater intelligence and skill become necessary to grow cotton successfully and that larger numbers of farmers must adopt the improved methods if production is to be maintained.

¹ Hunter, W. D. The boll weevil problem, with special reference to means of reducing damage. U. S. Department of Agriculture, Farmers' Bulletin 512, 46 p., 9 fig., 1912.

THE DEMAND FOR LONG-STAPLE COTTON.

The commercial factor is perhaps the most uncertain. The future of the long-staple industry in Louisiana, as well as in other parts of the United States, depends upon the extent to which this kind of fiber is used. To solve the agricultural problems of producing long-staple cotton may avail little if the manufacturing problems are to be solved on the basis of short staples. The tendency of the manufacturing world for many years past has been toward a substitution of short staples for long. The textile machinery has been improved, instead of improving the cotton.

Until a few decades ago all of the finer fabrics required long-staple cotton, but the successive steps of mechanical improvement have made it possible to spin finer and finer threads of short cotton and produce fabrics closely similar to those that had been made previously from long staples. Whatever the advantages of economy to the manufacturer, the substitution of short fiber for long is not in the interest of the consuming public. The short-staple fabrics are undoubtedly inferior in strength and durability. Indeed, this lack of durability is appreciated by manufacturers as tending to more frequent sales and larger profits. As long as it is more profitable to supply the short-staple fabrics they will doubtless continue to be furnished.

The substitution has gone on very gradually, of course, and without attracting any attention from the general public. Indeed, the public is now without any means of distinguishing long-staple fabrics from short, for the quality can no longer be judged, as formerly, by the fineness of the fabric. What may be considered as the last campaign of substitution dates back a few years, when a small cotton crop in Egypt aroused the apprehension of the manufacturers regarding the supply of that type of long-staple cotton. The result was that new lines of substitutes for Egyptian cotton fabrics, made of American Upland cotton, were placed on the market. Thus, the gradual substitution of shorter staples has gone on until now the manufacturers of thread consider theirs as the only branch of the textile industry that is really dependent on long-staple cotton. Thread, of course, must be strong, because its strength is so easily tested, but for most other purposes the substitution of short fiber is possible, if not already accomplished.

Even in articles like automobile tires that are popularly supposed to be made of Sea Island cotton, short fiber is being used. The Sea Island industry, instead of being stimulated by the manufacture of automobile tires, has stood still or declined, so that the planters of

this cotton in South Carolina, Georgia, and Florida have had difficulty in selling their recent crops.¹

If the tendency to substitution can be resisted by educating the public regarding the superior strength and durability of long-staple cotton the prospects of long-staple production in Louisiana and elsewhere will be greatly improved. The general use of inferior fiber in all of our ordinary clothing and household fabrics represents in the aggregate an enormous tax upon the consuming public. Indeed, it would be difficult to mention any other element of industrial waste that affects so many people and in so many ways as the use of inferior cotton fiber. That means of protection will be found eventually can hardly be doubted, but it is impossible to tell in advance how long it will take or to give any assurances regarding the immediate future of the long-staple industry. Although good prices have been realized in the last few years, the recent tendencies of the market have been distinctly downward, for no apparent reason unless it be that the success of further steps in the direction of substitution of short staples has resulted in a further reduction of the demand. A slight increase of production of long staples has occurred in the Carolinas, but hardly more than enough to supply the neighboring mills.

THE RELATION OF COTTON TO OTHER TROPICAL CROPS.

Cotton having become less reliable as a single crop on account of the boll weevil, there is greater need of combining it with other crops, in order to make the agricultural system stable as a whole. Hence, the possibility of introducing other profitable crops should receive attention. It would be a mistake to consider cotton alone if any special investigations or experiments are to be undertaken in the interest of the Louisiana cotton industry. A full development of the agricultural resources of Louisiana is likely to require the adoption of special crops as well as special methods of farming. In view of her fertility of soil, abundant moisture, and long growing seasons Louisiana must be considered as one of the richest, potentially, of the agricultural areas of the United States. The summer climate of Louisiana is really tropical and some of the tropical crops may be found useful.

While many tropical crops have been planted experimentally in Louisiana it can not be said that there has been any adequate canvass

¹ The possibility of establishing Sea Island cotton in Louisiana is often suggested, but the danger of weevil injury would probably be greater, and the Sea Island cotton does not seem likely to become a profitable crop on account of low yield, late maturity, and small size of bolls that increases the difficulty of picking. Some of these objections would also attach to the Egyptian cotton in Louisiana, though perhaps to a less extent. If grown at all, these cottons would have to be taken up by separate communities where no Upland cotton was planted. Another consideration with the Sea Island cotton is that active competition is being developed in some of the West Indies, where there are no boll weevils.

of the possibilities that lie in this direction. The behavior of a tropical plant when placed for the first time under new conditions may be altogether abnormal, as in the case of some of the new types of cotton introduced in recent years from tropical America. But by acclimatization and selection it has been possible in a few years to obtain early productive varieties from stocks that grew into large sterile bushes when first introduced.¹

The luxuriant growth of weeds lends another tropical aspect to agriculture in Louisiana. The weeds not only take full advantage of the opportunities of perennial growth, but are ready to spring up at any time that the land is left idle. One crop needs to follow another in quick succession in order to keep control of the weeds and at the same time keep down the expenses of cultivation. To insure the prompt succession of crops it is often necessary to plant two together or to sow one before the other is taken off. Thus, there may be another important advantage in shortening the growing season of cotton so that it can be raised in rotation with winter crops.

Other possibilities lie in the use of tree crops to assist in weed control or to give favorable conditions for other crops that thrive better with partial protection from the sun. We are accustomed to think of agriculture as an art that must be practiced out in the sun in the open field, but in tropical and subtropical countries many crops are grown as subcultures under the protection of trees. Thus, in some districts of southern Italy much of the agriculture is of this intensive character. Labor may be reduced by such methods, but intensive care and skill are required to combine crops successfully. Even cattle raising, which seems to have excellent prospects in Louisiana, must be done on a more intensive basis, as in the Tropics, for rich lands are soon covered with woody growth unless measures are taken to protect the grass or to maintain a rotation with other crops. Some of the tropical grasses might prove valuable in relation to the problem of weed control as well as for pasture or fodder.

In some important respects Louisiana must be considered as the most tropical part of the United States, as shown by the conjunction of three distinctively tropical crops—sugar, cotton, and rice. It is true that Florida and Texas extend farther south, but they do not afford to the same extent the tropical combination of rich alluvial soil and abundant moisture. The lands along the lower Mississippi also afford unusually favorable opportunities for developing methods of frost protection, especially with crops that could be saved by flooding from the river. Tree crops or perennials that will not survive frost are excluded, of course, but many annual crops are grown in different parts of the tropical and subtropical world, and some of

¹ Cook, O. F. Heredity and cotton breeding. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 256, 113 p., 19 fig., 6 pl., 1913.

these should prove adapted to the summer tropical conditions found in Louisiana. Southern China is a region with a variable continental climate, not unlike that of Louisiana, where many of the more hardy types of tropical plants have been cultivated for long periods of time and contribute to the support of enormous agricultural populations.

Even among the tropical plants already established in the United States there are some that are capable of much more extensive utilization than at present. The chayote and the dasheen may serve as illustrations of tropical crops now available for use in Louisiana. The chayote, or "mirliton," as it is usually called in the New Orleans markets, is a member of the squash family, producing a large climbing vine and an edible fruit with excellent possibilities of finding a place in northern markets. The reason why the chayote has not attracted more attention in Louisiana may be that the variety now grown about New Orleans is of only indifferent quality in comparison with others that are known to exist in Central America. Throughout the table-lands of Central America the chayote is the favorite garden vegetable and is grown in larger quantities than any other.¹

The dasheen is a superior variety of the taro, a plant used very extensively on the Pacific islands and other tropical countries. It is a starchy root crop, corresponding roughly to the potato, and in some respects actually superior. It grows in moist, rich land, and there are varieties that thrive even in swamps. The chief problem here, as with the chayote, is one of utilization, that is, of an effective introduction of the plant to the consuming public.²

The possibility of developing a stable and profitable system of agriculture in Louisiana is of more than local interest, on account of its relation to the national problem of control of the Mississippi River. The value of land for agricultural purposes is a very important factor in determining the feasibility of developing an effective system of river control. The introduction and establishment of more profitable crops might change the situation completely. Lands used for the production of cotton in the valley of the Nile are valued as high as \$1,000 an acre. Any approach to such values for agricultural lands in the Mississippi Valley would place the problems of river control and reclamation on an entirely different footing. But time is required for the realization of any such possibilities. Any new crop must pass through an experimental period. The habits of the plant and its reactions to the local conditions must be learned, cultural methods must be devised, and superior varieties must be bred or

¹ Cook, O. F. The chayote: A tropical vegetable. U. S. Department of Agriculture, Division of Botany, Bulletin 28, 31 p., 8 pl., 1901.

² Young, R. A. The dasheen, a root crop for the Southern States. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 127, p. 25-36, 3 figs., 1913.

acclimatized before the public can be expected to adopt the new crop, or even to appreciate its possibilities.

CONCLUSIONS.

The measures of improvement suggested in the preceding pages may be summarized as follows:

(1) *The investigation of new long-staple varieties of cotton and improved cultural methods*, or, if necessary, the development of new varieties and methods specially adapted to Louisiana conditions.

Early long-staple varieties and cultural methods that induce earlier fruiting have been developed recently by the Department of Agriculture, following a series of experiments in the drier parts of Texas and in irrigated districts of Arizona and California. But both the varieties and the methods are new and their value for Louisiana is still unknown. The possibilities of maintaining the long-staple industry in Louisiana or of utilizing the sugar lands for long-staple cotton must be determined by experiments under the local conditions.

(2) *The organization of cotton-growing communities* in order to secure more adequate protection against the boll weevil, produce uniform staples, and market the crop to better advantage.

The presence of the boll weevil introduces another variable factor into the cotton problem. Cotton being no longer a "sure" crop, the agricultural basis of the credit system of farming is impaired and the resulting disturbance of economic conditions is much more serious than could have occurred with any crop less confidently relied upon. This explains why social and economic considerations enter so largely, especially in a State like Louisiana, where the danger of weevil injury is greatest.

(3) *The education of the consumer* regarding the value of long-staple cotton as a means of securing strength and durability in clothing and other textile products.

Though no adequate development of the long-staple cotton industry is to be expected while the substitution of inferior cotton continues, this substitution is so wasteful industrially and so costly for the consuming public that it can hardly be allowed to continue indefinitely.

(4) *The acclimatization of other tropical crops*, so that cotton culture in Louisiana may become a branch of a safer and more diversified system of agriculture.

Tropical crops are especially indicated as a means of taking advantage of the local conditions of climate and soil that exist in Louisiana and also to avoid the competition of other States which have more favorable conditions for temperate crops. The agricultural resources of Louisiana will not be fully known until the possibilities of acclimatizing other tropical crops have been thoroughly tested.

THE USE OF CONGO RED IN CULTURE MEDIA.¹

By KARL F. KELLERMAN, *Physiologist in Charge of Soil-Bacteriology and Plant-Nutrition Investigations.*

INTRODUCTION.

In an earlier publication² mention was made of the value of a medium colored with congo red as a presumptive identification of the organism *Bacillus tumefaciens*, which is the cause of crown-gall of orchard trees, vines, etc., and which also produces tumors upon the roots of tomatoes, sugar beets, carrots, clover, alfalfa, and other plants. Certain strains of *Bacillus tumefaciens* if grown upon a suitable nutrient agar distinctly colored with congo red absorb the dye, thus staining the bacterial growth a vivid red and at the same time bleaching the layer of the culture medium. The absorption of the congo-red dye from the medium by the growing colony is usually such a decisive and striking action with many strains of *Bacillus tumefaciens* that it seemed desirable to test the diagnostic value of congo-red media for the common saprophytic bacteria.

DESCRIPTION OF TESTS OF CULTURES.

Through the courtesy of Prof. C.-E. A. Winslow 28 species of bacteria were secured from the American Museum of Natural History, and these, together with two strains of *Bacillus tumefaciens*, were plated out in Petri dishes in quadruplicate and were also grown in stab culture in various media. The fact that there had been recently isolated new species of bacteria³ which destroy cellulose and which are also able to grow luxuriantly upon the usual standard culture media, such as beef agar, beef gelatin, and milk, has suggested the possibility that many of the common saprophytic bacteria described by various authors might have the power of dissolving cellulose. Although the determination of a cellulose-dissolving function has no connection whatever with the diagnostic value of congo-red media, for mechanical reasons it has been convenient to study simultaneously the action of various species of bacteria upon cellulose media as well as upon congo-red media.

¹ Issued June 21, 1913.

² Kellerman, Karl F. The relation of crown-gall to legume inoculation. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 76, 6 p., 1 pl., 1911.

³ Kellerman, Karl F., and McBeth, I. G. The fermentation of cellulose. *Centralblatt für Bakteriologie* [etc.], Abt. 2, Bd. 34, No. 18/22, pp. 485-494, 2 pl., 1912.

McBeth, I. G., and Scales, F. M. The destruction of cellulose by bacteria and filamentous fungi. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 266, 50 p., 4 pl., 1913.

Four kinds of media were used:

Agar A.—The synthetic nitrogen-poor agar designed for the isolation of strains of *Bacillus tumefaciens*, prepared as follows: Water, 1,000 cubic centimeters; sugar, 10 grams; potassium phosphate (monobasic), 1 gram; magnesium sulphate, 0.2 gram; agar, 15 grams; and congo red, 0.1 gram.

Agar B.—Beef agar made in accordance with the recommendations of the committee upon standard methods of the American Public Health Association, with the addition of 0.01 gram of congo red to each liter.

Agar C.—A synthetic agar designed for the isolation of cellulose ferments of the following composition: Precipitated cellulose, 5 grams; agar, 10 grams; potassium phosphate (dibasic), 0.5 gram; magnesium sulphate, 0.5 gram; sodium chlorid, 0.5 gram; ammonium sulphate, 1 gram; calcium carbonate, 1 gram; tap water, 1,000 grams.

Agar D.—A synthetic agar similar to that described under agar C, except that peptone was substituted for ammonium sulphate.

Table I shows the action of the various cultures upon these culture media. In no case did subcultures react differently from the original culture. It should be remembered, however, that the writer has previously noted that strains of *Bacillus tumefaciens* isolated from different host plants show wide differences of absorptive power toward congo red and that the cause of this variation is as yet unexplained.

TABLE I.—Action of various species of bacteria upon congo-red media and upon cellulose media.

Species.	Congo-red media.		Cellulose media.		Species.	Congo-red media.		Cellulose media.	
	Agar A.	Agar B.	Agar C.	Agar D.		Agar A.	Agar B.	Agar C.	Agar D.
<i>Azotobacter chroococcum</i>	+	—	—	—	<i>Bacillus balticus</i>	—	—	—	—
<i>A. vinelandii</i>	—	—	—	—	<i>B. amylovorus</i>	—	—	—	—
<i>A. beijerinckii</i>	—	—	—	—	<i>B. capsulatus</i>	—	—	—	—
<i>Diplococcus gadidarium</i>	—	—	—	—	<i>B. fluorescens</i> (liquefaciens).....	+	+	—	—
<i>Bacillus tumefaciens</i>	++	+	—	—	<i>B. laetis</i>	—	++	—	—
<i>B. acidilactici</i>	—	—	—	—	<i>B. fluorescens</i>	+	+	—	—
<i>B. kiliensis</i>	—	—	—	—	<i>Actinomyces asteroides</i>	+	++	—	—
<i>B. alcaligenes</i>	—	—	—	—	<i>Bacillus prodigiosus</i>	+	++	—	—
<i>B. communior</i> "A 1".....	—	—	—	—	<i>B. acidophilus</i>	—	—	—	—
<i>B. aquatilis</i>	+	+	—	—	<i>Cladothrix dichotoma</i>	+	+	—	—
<i>Mycobacterium tuberculosis</i>	—	—	—	—	<i>Bacillus astheniae</i>	—	—	—	—
<i>Micrococcus flavus</i>	—	—	—	—	<i>B. aurantiacus</i>	+	+	—	—
<i>Bacillus proteus</i>	—	—	—	—	<i>B. butyriscus</i>	+	++	—	—
<i>B. niger</i> (liquefaciens).....	—	—	—	—	<i>B. lactimorbi</i>	+	+	—	—
<i>B. carotovorus</i>	—	+	—	—	<i>B. communior</i> (rubra).....	—	—	—	—
<i>B. stewartii</i>	—	—	—	—	<i>B. rutilescens</i>	+	+	—	—
<i>B. melonis</i>	—	+	—	—	<i>B. campestris</i>	—	—	—	—
<i>B. danyasz</i>	—	—	—	—	<i>B. juglandis</i>	+	+	—	—
<i>B. plicatus</i>	—	+	—	—	<i>B. candicans</i>	—	—	—	—
<i>B. phosphorescens</i>	—	—	—	—	<i>B. fluorescens</i> (tenuis).....	—	—	—	—
<i>B. gasiformans</i>	—	—	—	—	<i>B. saccharolyte</i>	—	—	—	—
<i>B. communior</i> (lutea).....	+	—	—	—	<i>B. cyanus</i>	+	—	—	—
<i>Micrococcus citreus</i>	—	—	—	—	<i>B. arborescens</i>	—	+	—	—
<i>Bacillus aerogenes</i>	—	—	—	—	<i>Denitrifier</i>	—	+	—	—

CONCLUSIONS.

It is interesting to observe that none of the organisms tested up to the present time show as strong an absorption of dye from the synthetic nitrogen-poor medium as do certain strains of *Bacillus tumefaciens*, while upon beef agar four other species exhibit the greatest activity. Practically all stab and streak cultures show more or less absorption along the edge of the broken agar surface, but this seems to be due to the staining of slime where the bacterial growth is oldest and to the staining of dead bacteria killed in transferring. The living bacteria themselves, however, of at least certain strains of such species as *Bacillus tumefaciens*, *B. butyricus*, *B. prodigiosus*, *B. lactis*, etc., can absorb congo red, which, like the relation of bacterial strains to gentian violet described by Churchman and Howard,¹ would seem to indicate that this phenomenon is associated with some protoplasmic function. Observations upon bacterial cells of *Azotobacter chroococcum* impregnated with congo red show that upon cell division at least frequently one red and one colorless cell are formed.

¹ Churchman, John W., and Howard, Michael W. The selective action of gentian violet on closely related bacterial strains. *Journal of Experimental Medicine*, v. 16, no. 6, pp. 822-830, 1912.

[Cir. 130]

A SIMPLE AND ECONOMICAL METHOD OF BURNING LIME.¹

By J. H. ARNOLD, *Agriculturist*, and JOHN E. NICHOLS, *Agent, Office of Farm Management*.

INTRODUCTION.

This paper represents the results of the experience in burning lime on the farm of Benjamin Cherry, in Warren County, Ky., where two kilns were burned during the preceding winter and the spring of 1913. The details of the operation are given so that any farmer in Kentucky, West Virginia, or Tennessee who has good limestone on his land may burn lime in a similar manner.



FIG. 1.—Wood bottom of kiln and first layer of limestone.

CONSTRUCTION OF THE KILN.

The kiln was located on top of a bed of limestone, the greater part of which was exposed or very near the surface. Poles and slabs were placed lengthwise on the ground, making a layer 30 feet long and 16 feet wide, as shown in figure 1. The largest poles, 8 or 10

inches in diameter, were used for the outside rows in order to make a more stable foundation. The smaller poles and slabs were placed between the large outside poles; and these made up the layer, except for a strip 2 feet wide in the middle, where small wood and kindling were placed the entire length of the kiln. Chinks between the poles and slabs were filled with fine wood and cornstalks.

Fine coal was then placed as a second layer to a depth of 2 inches. On top of the coal was placed a 4 or 5 inch layer of limestone, crushed to the size of a man's head or smaller. (Fig. 2.) Another layer of coal was then added and this was followed by a layer of limestone 12 to 14 inches thick. Alternate layers of coal and stone were added to these until the pile was 7 or 8 feet high. The sides



FIG. 2.—The kiln in the third step of building. A layer of coal is being added to cover the layer of limestone.

were gradually drawn in, making the pile somewhat pyramidal in shape and drawing it to a peak, and were then coaled up by shoveling on as much as the crevices would hold. The kiln was then ready to be fired.

METHOD OF BURNING.

A fire was started on the windward end near the middle, where the strip of kindling had been placed. This gradually began to burn. In a day or two, as the fire began to burst out of the sides, dirt was shoveled over it to smother the fire and keep it from burning too rapidly. The burning of the kiln continued about two weeks. After it had cooled off, the dirt was removed in order to

allow the rains to sink in and to slake the lime, after which it was ready to be used on the land. (Fig. 3.)

COST OF BURNING.

It is estimated that the kiln referred to contained about 2,400 bushels, or nearly 87 tons, of lime. The expenses were as follows:

Quarrying stone:

Labor, 1 man for 2 weeks-----	\$12. 00
Dynamite -----	1. 00
Coal, 453 bushels, or 16½ tons, at 8 cents per bushel-----	36. 24
Wood (4 loads)-----	2. 50
Labor in making and tending kiln-----	18. 36
Miscellaneous work and materials-----	10. 00
Total -----	80. 10



FIG. 3.—A heap of burnt lime ready to apply to the land. The dirt was removed when the burning was finished and the rains have slaked the lime.

On a kiln of the same dimensions built on a neighboring farm the expenses were somewhat higher, as follows:

Coal -----	\$45. 00
Wood -----	6. 00
Hauling wood and stone-----	6. 00
Labor in quarrying and in making and tending kiln-----	36. 00
Total -----	93. 00

On each of these farms the labor was all hired, but in many cases this could be supplied entirely by the farmers during the winter,

when little else could be done, and at the same time the land could be cleared of stone and cultivated. The coal could have been secured for 6 cents a bushel if bought during the summer.

CAUTION REGARDING THE USE OF LIME.

There is an old English proverb which, in substance, says that the use of lime on land makes the father rich and the son poor. Caustic lime should be used with good judgment, and no more should be applied than the land requires in order to neutralize it. From 800 to 2,000 pounds to the acre is the quantity of caustic lime usually applied, or from 2,500 to 5,000 pounds of ground limestone. Caustic lime should never be scattered on growing plants.

Lime uses up the humus in the soil very fast; hence, this important ingredient of the soil must be constantly and liberally supplied by plowing under vegetable matter in the form of green cover crops or stable manure.

RELATIVE EFFICIENCY OF AGRICULTURAL LIME AND GROUND LIMESTONE.

On three farms, two in Warren County, Ky., and one in Jefferson County, W. Va., the average cost of burning lime according to the methods just described was about \$1 per ton of finished product, burnt or stone lime. On one of these farms the average cost of grinding the limestone to such fineness that the largest particles would pass through a 10-mesh sieve, which is practically fine enough, was about \$1 per ton, including the cost of quarrying. Of good burnt lime 56 pounds is equivalent in agricultural value to 100 pounds of finely crushed limestone or to 74 pounds of "hydrated" lime. The product known as "agricultural lime," "ground lime," etc., is usually partly hydrated and partly carbonated, and hence is a little less valuable than pure hydrated lime.

REFERENCES AND SOURCES OF SCIENTIFIC INFORMATION.

Most of the experiment stations in the eastern section of the United States have carried on experiments in liming the land. The following bulletins will be of interest to farmers in the three States to which this circular applies:

ELLET, W. B.

Lime for Virginia farms. Virginia Agricultural Experiment Station, Bulletin 187, 48 p., 23 fig., 1910.

HITE, B. H., and KUNST, F. D.

Commercial fertilizers. Complete report for 1909. West Virginia Agricultural Experiment Station, Bulletin 125, 102 p., 1910.

PATTEN, A. J., and JEFFREY, J. A.

Lime for agricultural purposes. Michigan Agricultural Experiment Station, Circular 11, p. 79-82, 1911.

[Cir. 130]

MOOERS, C. A.

Fertility experiments in a rotation of cowpeas and wheat. Pt. 1. The utilization of various phosphates. Tennessee Agricultural Experiment Station, Bulletin 90, p. 57-90, 1910.

WHEELER, H. J.

The liming of soils. U. S. Department of Agriculture, Farmers' Bulletin 77, ed. 2, rev., 19 p., 1899.

GRINSLEY, G. P.

The limestone and lime industry of West Virginia. West Virginia Geological Survey [Report], v. 3, chap. 17-22, p. 312-422, 6 fig., 11 pl. [1906]. [Cir. 130]



U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 131.

WILLIAM A. TAYLOR Chief of Bureau

MISCELLANEOUS PAPERS.

Cultural Characters of the Chestnut-Blight Fungus and Its Near Relatives	{ C. L. SHEAR and NEIL E. STEVENS
Measuring Hay in Ricks or Stacks	{ H. B. McCLURE, W. J. SPILLMAN, and J. W. FROLEY
Cellulose as a Source of Energy for Nitrogen Fixation	I. G. McBETH

Issued July 5, 1913.

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1913.

BUREAU OF PLANT INDUSTRY.

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[Cir. 131]

CULTURAL CHARACTERS OF THE CHESTNUT-BLIGHT FUNGUS AND ITS NEAR RELATIVES.¹

By C. L. SHEAR, *Pathologist in Charge of Small-Fruit Diseases*, and NEIL E. STEVENS,
Forest Pathologist.

INTRODUCTION.

The chestnut-blight fungus *Endothia parasitica* (Murr.) And. and And. has been found to have two or three rather closely related species in this country, as follows: *Endothia radicalis* (Schw.) DeNot., *E. radicalis mississippiensis*, and *E. gyrosa* (Schw.) Fr. One or two other species have been found, but are not likely to be confused with *E. parasitica*.

Endothia radicalis (Schw.) DeNot. has already been well described by the Andersons² as *E. virginiana*, and also by Clinton³ as *E. gyrosa*.

A study of the type specimen of *Sphaeria radicalis* Schw., made by the senior writer,⁴ has shown that this name properly belongs to the plant having narrowly oval ascospores, usually ranging from 6 to 9 by 2.5 to 3.5 microns. In general macroscopic appearance this species very closely resembles *Endothia parasitica*, and we were at first inclined to the belief that the two were not specifically distinct, but after a careful study of hundreds of specimens, cultures, and inoculations of both species from many localities no series of intergrading forms, either morphological or physiological, has been found. At first glance the form described below might be so considered, but it is quite distinct and constant in its cultural characters. Unless such intergrading forms should be discovered later there seems to be no way of escaping the conclusion that the two organisms are specifically distinct, according to the most conservative taxonomic standard of species prevailing at present in mycology. The lack of fluctuating variations in these organisms, both in nature and in artificial cultures, is in striking contrast with the species of *Glomerella*, which, according to the senior writer's experience, showed few or no stable characters of any kind.

¹ Issued July 5, 1913.

² Anderson, P. J., and Anderson, H. W. The chestnut-blight fungus and a related saprophyte. *Phytopathology*, v. 2, no. 5, pp. 204-210, 1912.

³ Clinton, G. P. The relationships of the chestnut-blight fungus. *Science*, n. s., v. 36, no. 939, pp. 907-914, 1912.

⁴ C. L. Shear. The type of *Sphaeria radicalis* Schw. To appear in *Phytopathology*, v. 3, no. 3, 1913.

Endothia radicalis mississippiensis subsp. nov.—The writers are giving this name tentatively to a plant of which only four collections have thus far been seen. These were all found on dead chestnut coppice in northern Mississippi. In morphological characters it does not appear to differ appreciably from *E. radicalis*, but in cultures it shows constant and easily recognized differences. In pycnospore streak cultures on potato agar +6 or +7 Fuller's scale this variety produces less aerial growth along the streak than *E. parasitica*. When 5 or 6 days old the surface growth is xanthine orange by reflected light. When 2 weeks old it shows the most marked characters, being grenadine red by transmitted light and producing no spore masses. On corn meal the color of the mycelium becomes orange chrome at the end of a week and the pycnidia are larger and less numerous than in *E. parasitica*. The perilla-purple color developed in this medium by *E. radicalis* appears very tardily or not at all in cultures of this variety. There is no evidence yet that it is any more parasitic in tendency than *E. radicalis*. More material and data are necessary to determine satisfactorily its taxonomic status.

Endothia gyrosa (Schw.) Fr.—Under this name we shall treat of the fungus which Clinton ¹ calls *E. radicalis* (Schw.?) Farl. This species is easily recognized in its ascospore stage by its long, narrow, usually nonseptate ascospores, mostly measuring from 7 to 11 by 1.5 to 2.5 microns. A discussion of the identity of this species will be given in a later publication.

Since these organisms when found on dead plants are not easily distinguished from *Endothia parasitica* by macroscopic characters in the field, nor always with certainty from microscopic studies, especially when only the pycnidial fructifications are found, it is desirable to have some other certain means of diagnosis in case of doubt. With this end in view the cultural characters and reactions of the organisms have been studied on various culture media. Over 2,000 cultures have been studied, including 19 different collections of *E. parasitica* selected from 100 or more, mostly from *Castanea* species, and a few from *Quercus*, ranging from New Hampshire to southern Virginia, 24 European collections of *E. radicalis* on *Castanea sativa* from Italy and Switzerland, and 54 American specimens taken from over 100 collections on *Quercus* species and *Castanea dentata*, ranging from southeastern Pennsylvania and Ohio to South Carolina and Alabama; also 4 collections of the Mississippi form on *Castanea dentata* from northern Mississippi and 34 collections of *E. gyrosa* selected from 140 on *Quercus* species, Liquidambar, Fagus, and *Castanea dentata* from Connecticut and Michigan to Florida and Texas.

¹Clinton, G. P. Chestnut-bark disease. Connecticut Agricultural Experiment Station Annual Report, 1912, pt. 5, p. 422, 1913.

PREVIOUS CULTURE WORK.

Clinton, the Andersons, Pantanelli, and Fulton have already made contributions to this subject. Clinton,¹ 1908, describes cultures of *Endothia parasitica* on Lima-bean agar. Pycnosporos were produced and the growth gradually changed from whitish to a bright orange color. The expelled pycnosporos were described as lemon yellow, later becoming a chestnut brown. In 1912² and 1913³ Clinton described cultures of *E. gyrosa*, which is the *E. radicalis* of the present writers and will be so named hereafter in this paper, on potato, Lima-bean, and oat agars. The following differences between this species and *E. parasitica* were pointed out: *E. parasitica* fruited earlier and more abundantly than *E. radicalis* and had more numerous and smaller fruiting bodies than the latter; *E. parasitica* also produced a less luxuriant aerial growth, the embedded mycelium being much more highly colored. In his last paper, 1913,³ Clinton gives further accounts of cultures, emphasizing the points already mentioned and giving five differences in the behavior of the two. The principal point, in addition to those just mentioned, is that *E. parasitica* produces more abundant, earlier, smaller pycnidia, which are embedded in the surface, while *E. radicalis* forms fewer, elevated, distinct pustules, rarely hidden by the exuding spores. Cultures on potato-juice agar, with various quantities of tannic acid, were also compared. Clinton found that *E. parasitica* grew in higher percentages of the tannic acid used and produced a more evident development of mycelium than *E. radicalis*.

The Andersons⁴ pointed out the differences between cultures of *Endothia parasitica* and *E. radicalis* (*E. virginiana*) grown on potato agar and on sterile chestnut twigs. They found practically the same differences between the two organisms on the potato agar as described by Clinton, though somewhat more detail is given in regard to the development of the characteristic features. They also pointed out, for the first time, the differences in the growth of the two species on sterile chestnut twigs. *E. parasitica* produced a short, white, weblike growth on the surface of the twigs, with heavier masses of mycelium, which later became orange colored where pycnidia developed, while *E. radicalis* developed a fluffy orange

¹ Clinton, G. P. Chestnut-bark disease, *D'aporthe parasitica* Murr. Connecticut Agricultural Experiment Station, 31st-32d Annual Reports, [1906]-1908, p. 879-890, 1908.

² Clinton, G. P. The relationships of the chestnut-blight fungus. *Science*, n. s., v. 36, no. 939, p. 907-914, 1912.

³ Clinton, G. P. Chestnut-bark disease. Connecticut Agricultural Experiment Station, Annual Report, 1912, pt. 5, p. 422, 1913.

⁴ Anderson, P. J., and Anderson, H. W. The chestnut-blight fungus and a related saprophyte. *Phytopathology*, v. 2, no. 5, p. 204-210, 1912.

mycelial growth almost filling the tube, at first white; but changing to orange within a few days.

Pantanelli¹ describes cultures of both species on glucose agar to which extract of chestnut bark had been added. He says the appearance and quantity of mycelium was the same in both, but *Endothia radicalis* developed a characteristic "giallo-aranciato" yellow-orange color less rapidly than *E. parasitica*. He also grew both on sterile chestnut branches and roots. On the roots *E. radicalis* grew slowly and *E. parasitica* much less or not at all.

Fulton² mentions cultures on artificial media, stating that *Endothia parasitica* grows most readily on an acid medium.

Heald and Gardner³ found that cultures from pycnospores and ascospores of *E. parasitica* could be distinguished by the earlier appearance of the growth from ascospores in plates. A 3 per cent dextrose agar +10 was used.

CULTURE MEDIA.

The following are the principal media and substrata upon which the organisms have been grown: Sterile chestnut twigs, Raulin's fluid, potato cylinders, chestnut-twigg agar, beef agar -15 Fuller's scale, prune agar +11 to -15, corn-meal agar +11 to -15, potato agar +15 to -15; also starch, oatmeal, rice, and white corn meal in flasks. The stock cultures from which subcultures were made were kept on corn meal in flasks. The subcultures, unless otherwise stated, were made by transferring pycnospores from the stock cultures. The cultures were kept in dark cases at ordinary room temperatures, except where otherwise mentioned.

LIGHT TESTS.

Two series of spore streaks of *Endothia parasitica* and *E. radicalis* on potato agar +6 were placed in a beaker in bright light on a window sill. Duplicate series were wrapped in heavy opaque paper projecting well above but not covering the plugs.

After two weeks *Endothia parasitica* showed slightly more orange color in the darkened tubes. This difference was probably due, however, to the fact that evaporation was less in the dark tubes rather than to the want of light.

¹ Pantanelli, E. Su la supposta origine europea del cancro americano del castagno. Atti, Reale Accademia dei Lincei, ser. 5, Rendiconti, Classe de Scienze Fisiche, Matematiche e Naturali, v. 21, fasc. 12, p. 869-875, 1912.

² Fulton, H. R. Recent notes on the chestnut bark disease. Conference Called by the Governor of Pennsylvania to Consider Ways and Means for Preventing the Spread of the Chestnut Tree Bark Disease. Harrisburg, p. 48-56, 1912.

³ Heald, F. D., and Gardner, M. W. Science, n. s., v. 37, no. 963, p. 916-917, 1913.

MOISTURE TESTS.

Three series of several flasks each on corn meal were made with different quantities of water, using *Endothia radicalis* and *E. parasitica*, as follows:

Series 1.—Corn meal. 10 grams, plus water, 10 cubic centimeters.

Series 2.—Corn meal, 10 grams, plus water, 15 cubic centimeters.

Series 3.—Corn meal. 10 grams. plus water, 20 cubic centimeters.

The two species grew equally well in each series. There was, however, a marked difference as to the time of appearance of spores in the different series. Spore production began at about the same time with both species in the same series.

At the end of two weeks in series 1, *Endothia parasitica* showed numerous small spore pustules. *E. radicalis* at the same age showed but four pustules in each flask. These pustules were much larger than those of *E. parasitica*. In series 2 both species showed an intermediate condition of development. In series 3 *E. parasitica* developed somewhat more mycelium than in series 1, and there were only a few scattered spore pustules. *E. radicalis* produced more mycelium than in series 1 and only two or three very small pustules.

At the end of two months in series 1 *Endothia parasitica* had covered the entire surface with small confluent spore masses. *E. radicalis* now showed numerous large pustules with extruding spore masses. Series 2 was intermediate, as before. In series 3 *E. parasitica* showed a large number of separate small spore pustules with white mycelium between them, while *E. radicalis* showed but few stromata, much enlarged and extruding large spore masses.

It will be noted that the greatest spore production occurred in the cultures having the least quantity of water added.

TEMPERATURE TESTS.

Fulton¹ found that conidia germinate best at a temperature of 60° F. (15.5° C.) and distinctly less rapidly at 10 degrees above or below the optimum. Ascospores germinate best at a temperature of about 70° F., but give a good percentage of germination at 85° and 45° F. He also found that early growth is most rapid at the optimum temperature for germination.

A few experiments have been made by the writers to determine the temperature relations of the organisms.

Series 1 (six tubes of each) on potato agar+7.—At the end of 14 days the cultures kept at 40° C. showed no growth in any case.

At 35° C. *Endothia parasitica* showed a small amount of an irregular rough leathery growth, orange next to the agar. *E. radicalis* showed

¹ Fulton, H. R. Op. cit.

only a slight amount of growth in a few tubes. *E. gyrosa* showed about the same amount of growth as *E. parasitica*, but the growth was decidedly more normal in appearance. Only two of the tubes of *E. radicalis* which had shown no growth at 35° C. began to grow when kept at room temperature.

In one week at room temperature, 22° to 24° C., *Endothia parasitica* and *E. gyrosa* nearly, if not quite, covered the surface of the medium, while *E. radicalis* showed but little less growth. In 14 days all species at room temperature completely covered the surface of the medium with a typical mycelium. This appears to be at least nearer the optimum temperature than any other used.

At 18° C. growth in all species was much less than at room temperature. There was, however, a marked and typical difference between *Endothia parasitica* and *E. radicalis*, which was more pronounced than is usually the case at room temperature. The differences were practically the same as those described for potato-agar cultures on page 11.

At 16° C. the cultures differed very little from those at 18° C.

At 7° C. there was no growth whatever.

Series 2 (six tubes of each) on potato agar +6.—At the end of 15 days cultures at 40° C. showed no growth.

At 35° C. *Endothia parasitica* showed a slight abnormal growth, as described in series 1. *E. radicalis* showed no growth whatever. *E. gyrosa* showed slightly more than *E. parasitica* and was decidedly more normal in appearance. Transferred to room temperature about half of the *E. radicalis* cultures grew.

Series 3 on corn-meal and potato agars.—In this test there was no noticeable difference in the behavior of the fungi on these two media. Cultures from over 70 different specimens chosen from the extremes of the known ranges of the several species and from near the center were used. These cultures were made partly from spores and partly from mycelium. In no case was any difference noted in the cultures of the same species from the various localities or different inoculating material. At the end of 24 days there was no growth in any at 40° C.

At 35° C. *Endothia parasitica* showed an abnormal growth, as described for series 1. Material from New Hampshire and from Virginia showed no difference. *E. radicalis* showed no growth. *E. gyrosa* showed growth about equal to that of *E. parasitica*. Cultures from Michigan and Alabama showed no difference in the amount of growth.

At 32° C. *Endothia parasitica* produced a fairly abundant growth, which had taken on the characteristic orange color. *E. radicalis* showed but a slight amount of growth. *E. gyrosa* showed a little more development than *E. parasitica*.

At 30° C. there was less growth in all cases than at room temperature. *E. parasitica* showed slightly less orange than at room temperature. At room temperature the growth was typical, as described for series 1. At 16° C. the growth in all was almost exactly as described for 18° C., series 1. At 12° C. all were typical in character, but less in amount than at 16° C. At 9° C. there was very slight growth, about uniform in all. At 7° C. there was no growth.

From these records it will be noted that the minimum temperature for all was 9° C. and that all failed to grow at 7° C. The maximum temperature for *Endothia parasitica* and *E. gyrosa* was 35° C. The maximum for *E. radicalis* was 32° C. At higher temperatures there was no growth. Thus, there is apparently a difference of 3 degrees C. between the maxima of *E. parasitica* and *E. radicalis*. What practical or biological significance this fact may have is not clear to the writers. Owing to a lack of facilities for controlling temperatures between 18° C. and 28° C. the optimum for the organisms could not be accurately determined. The optimum appears to be near ordinary room temperature, i. e., about 22° to 24° C.

DESCRIPTION OF CULTURES.

In the following descriptions of cultures all names of colors are taken from Ridgway's ¹ recent work on color nomenclature.

No growth whatever was obtained on Raulin's fluid, beef agar -15, corn-meal agar +11, and prune agar +11. In the two last-named cases the media were so acid that they would not solidify.

Potato cylinders.—On ordinary potato cylinders sterilized in an autoclave at 115° C. all the organisms grew satisfactorily, but no differential characters of value appeared before the cultures dried up.

Chestnut twigs.—Cultures on sterilized chestnut twigs showed the same characteristics of growth for *Endothia parasitica* and *E. radicalis* as described by the Andersons. These species are most easily distinguished on the cut surfaces of the twigs.

Endothia radicalis mississippiensis showed at the end of six weeks a cadmium-orange mycelium on the cut surfaces of the twigs, while *E. radicalis* and *E. parasitica* were cadmium yellow in the colored portions.

Endothia gyrosa showed at first an ochraceous-buff growth on the cut surfaces and later changed to nearly the same color as *E. radicalis*. *E. gyrosa* may, however, even in old cultures, be distinguished from the others by the irregular tubercles or subpulvinate masses of mycelium.

¹ Ridgway, Robert. Color Standards and Color Nomenclature. Washington, 43 p., 53 pl., 1912.

CULTURES ON CHESTNUT-TWIG AGAR.

The chestnut-twig agar was prepared by the following formula:

To 275 grams of 1 or 2 year old chestnut branches add 550 cubic centimeters of distilled water and boil over an open flame for one-half hour. Filter the juice and make up to 550 cubic centimeters with distilled water. To 50 parts of this infusion add 100 parts of distilled water and 2 per cent of agar flour. Steam for one-half hour, filter, tube, and autoclave for 15 minutes at 115° C.

Several different strengths of the infusion were tried, but the formula given above proved the most satisfactory. The series of cultures on this medium gave readily distinguishable differences between *Endothia parasitica* and *E. radicalis*, but growth was too slow for general use. After one month *E. parasitica* showed numerous spore masses and an abundant white surface growth, but no aerial hyphæ. *E. radicalis* showed no spore production and had considerable white, fluffy, aerial mycelium at the upper edge of the agar. At the end of two months a few of the tubes of *E. radicalis* showed one or two spore pustules, while the others were unchanged.

CULTURES ON PRUNE AGAR.

Prune agar was prepared according to the following formula:

Take four ordinary prunes and add 1 liter of water. Boil over an open flame for one hour, being careful not to break the skin of the prunes. Strain through gauze, make up to the original amount with distilled water, and add 2 per cent of agar flour. Steam for three-quarters of an hour, filter, and tube. Autoclave for 15 minutes at 115° C.

Cultures of *Endothia parasitica* 3 weeks old on this medium, -15 Fuller's scale, produced a great abundance of pycnidia with slimy spore masses exuding, but no aerial mycelium. *E. radicalis* from both American and European material produced few small pycnidia and spore masses but somewhat more aerial mycelium, especially at the bottom of the tubes. The other species were not grown on this medium.

CULTURES ON CORN-MEAL AGAR.

Formula: To 50 grams of corn meal add 1 liter of water. Keep in a water bath for 1 hour at a temperature of 58° C., never over 60° C. Filter through paper, add 1½ per cent of agar flour, steam for 1½ hours, filter, and tube. Autoclave for 15 minutes at 115° C.

Corn-meal agar made by the above formula generally tests +3. This has proved the best agar medium for the production of pycnospores. There is also a constant difference in the cultural characters of the different species on this medium. This difference is, however,

much more striking on unslanted tubes. Upright tubes have the disadvantage of a small surface, but this is more than offset by the fact that the greater depth of agar gives a much more uniform moisture supply to the fungus. The most characteristic differences upon this medium appear in cultures from 6 weeks to 2 months old. The earlier stages are also sufficiently distinct for easy identification. In the older stages *Endothia parasitica* showed a scant white growth of surface mycelium with several prominent pycnidial pustules clustered near the center and of a slightly darker shade than the raw sienna of Ridgway. *E. radicalis*, on the other hand, produced a rather abundant deep chrome mycelium with usually one or two smaller, less conspicuous pycnidial pustules. *E. radicalis mississippiensis* on this medium resembled *E. parasitica* in producing only a very scant surface growth of mycelium, but the color was between cadmium yellow and raw sienna. The pycnidial pustules were more numerous than in *E. radicalis* and smaller and more scattered than in *E. parasitica*.

At this age *Endothia gyrosa* showed rather abundant, felty white mycelium flecked with capucine buff but no pycnidia. Occasionally in old cultures of this species small pycnosporous threads were produced. On corn-meal agar -15 the growth was slow, but an abundance of spores was produced.

CULTURES ON POTATO AGAR.

The formula for the potato agar used is as follows:

Put clean pared potatoes through a meat grinder. To 1,000 grams of the potato pulp add an equal quantity of distilled water. Stir thoroughly and let stand in an ice box for an hour, with occasional stirring. Strain through gauze of medium mesh. Make up to three times the weight of the original pulp with distilled water. Steam for 1 hour, filter through cotton and paper, and make up to 3,000 cubic centimeters with distilled water. Add 1½ per cent of agar flour, steam for 1 hour, filter through cotton and paper, tube, and autoclave for 15 minutes at 115° C.

In practice it was found that the potato agar prepared according to this formula varies widely in acidity and probably in some other respects. To reduce this variation a large quantity of potato juice was made from a uniform lot of Burbank potatoes. This was placed in 1,000-cubic-centimeter flasks, tightly plugged and kept in a refrigerator. The juice was then made up into agar tubes as needed. It was found that this agar varied less than 1 per cent in acidity, changing from +7 to +6 during 5 months.

Endothia parasitica.—Pycnosporous streaks of *Endothia parasitica* and *E. radicalis* on this potato agar agreed closely with that described

by Anderson. At the end of 3 or 4 days *E. parasitica* at room temperature showed a short, fluffy, white, aerial growth along the streak. The surface of the mycelium was orange by transmitted light, while by reflected light it was between raw sienna and antique brown at the sides. Within 6 days the mycelium, especially at the base of the agar slant, took on a peculiar granular metallic appearance, due apparently, in part at least, to the character of the mycelium and in part to the minute water drops scattered over the surface. This portion of the culture was light orange yellow by reflected light and orange by transmitted light. The peculiar surface appearance might perhaps be called "brassy." This metallic appearance has been found to be the most constant and reliable distinguishing character of *E. parasitica* on potato agar. In 12 to 14 days small pycnidial pustules appeared in the upper portion of the tubes, and the agar just below the mycelium became warbler green, changing later to olive green.

Endothia radicalis.—Pycnosporer streak cultures of this species vary widely as to the amount and time of the appearance of color. Occasionally tubes showed a small orange area in 5 days. Many tubes showed the same color in 1 week, while others produced no orange color whatever. In no case did cultures of *Endothia radicalis* produce the brassy metallic surface so characteristic of *E. parasitica*. Pycnidia were few and more scattered than in *E. parasitica* and spore masses did not begin to appear until the third or fourth week. A slight amount of warbler-green color appeared in the medium occasionally at this age, but never so conspicuously as in *E. parasitica*.

Cultures made by transfer of mycelium of *Endothia radicalis* to potato agar were found to vary widely as to the rate of growth, color, and general appearance. The variations in such cultures were so great as to make them much less reliable than spore cultures.

Endothia radicalis mississippiensis.—This produced less fluffy aerial mycelium along the spore streak than *Endothia parasitica*. After 5 or 6 days the fungus showed an orange color by transmitted light and was indistinguishable in this respect from *E. parasitica*. The character of the surface was somewhat different, however, and by reflected light appeared xanthine orange. When 2 weeks old this form differed still more markedly from *E. parasitica* in color, being grenadine red by transmitted light and showing no spore masses.

Endothia gyrosa.—This species developed more slowly than any of the others, producing a rather abundant aerial growth, which was felty rather than fluffy. The color was white flecked with capucine buff, and no spore masses were produced.

On potato agar of high acidity, i. e., from +11 to +15, no spores were produced in any of the species, even in very old cultures. In agar of lower acidity, spore production was proportionately greater,

as well as earlier in appearance. The high-acid media, however, gave the distinctive colorations described more quickly than those of lower acidity.

CULTURES ON OATMEAL.

The oatmeal is prepared as follows: Put 10 grams of oatmeal in 100-cubic-centimeter Erlenmeyer flasks. Add 20 cubic centimeters of distilled water. Stir until thoroughly mixed, plug, and autoclave for 25 minutes at 120° C.

Starch, rice, and white corn meal are prepared in the same manner, but cultures of all species developed so slowly on starch in flasks that this medium was abandoned. Corn meal in 1-inch test tubes prepared in the same manner was tested with 10 strains of *Endothia parasitica* and 30 of *E. radicalis*, using about an equal number of American and European strains. This did not show the same color reactions as in the flasks. Only about half of the tubes of *E. radicalis* showed purple before the medium dried up.

Endothia parasitica.—Cultures 1 week old showed a superficial, more or less erect, pure white cottony growth covering the whole surface of the medium. *Endothia parasitica* on the same medium 12 days old began to show spore masses extruding through the white mycelium near the point of inoculation. At the end of a month the spore masses, which were pale yellow ochre, were rather numerous, of medium size, and scattered over the surface of the culture. The older portions of the mycelium in contact with the glass were orange. At 6 weeks of age cultures showed more or less sunken patches very near flame scarlet, whereas cultures on other media of the same age showed no change.

Endothia radicalis.—Cultures at the end of a week showed a growth about as luxuriant as in *Endothia parasitica*, but the aerial portion had a slightly coarser and more tufted appearance. The color ranged from light orange yellow through perilla purple to light pinkish lilac at the margin. The older portion of the culture in contact with the glass was perilla purple, apparently in both mycelium and medium. On the same medium at the end of a month there was a somewhat greater development of mycelium, with a more compact surface and irregular small cushionlike masses. The perilla-purple color had almost entirely disappeared from the surface, but could be seen through the oatmeal on the bottom and sides of the flask. The mycelium in contact with the flask was orange. No spore masses were present.

Endothia radicalis mississippiensis.—Cultures 1 week old showed a buff growth covering the surface of the medium. About three-fourths of the older portions were orange chrome. The superficial

growth was very similar in character to that of *Endothia parasitica*, especially the pure white portion near the margin. The older portions appeared slightly coarser and tufted. Cultures on the same medium 1 month old showed a still coarser aerial growth, with the very youngest portions nearly white, but the greater part of the growth was orange rufous. This color was also present wherever the mycelium came in contact with the flask. The culture medium showed no change in color. Spore masses appeared in these cultures in about the same time as in *E. parasitica*. They were scattered and inconspicuous on account of being practically the same color as the older portions of the mycelium, and were practically the same size and character as in *E. parasitica*.

Endothia gyrosa.—Cultures made from mycelium, no pycnosporos being available, showed a superficial growth covering the surface of the medium. The mycelium was of a softer and more cottony appearance than in the other species, and pure white except a small portion at the point of inoculation, which was ochraceous buff. Cultures a month old showed a more compact surface, which was rather pulvinate or pustulate. The spore masses were of the same ochraceous-buff color, and the other portions lighter. The margin in contact with the flask was dark brown.

CULTURES ON RICE.

Endothia parasitica.—In cultures 1 week old the growth covered about one-fourth of the surface of the medium with a scanty superficial mycelium. The mycelium was white, flecked with buff yellow, the color being more conspicuous at the margin. The color of the medium was unchanged. No spore masses were found.

The same fungus in cultures 1 month old showed the surface growth unchanged in character, but dirty white with numerous small spore masses which were somewhat confluent near the center of the growth and showing a pale yellow ocher color. The medium was mostly tea green on the bottom, streaked with lighter green, giving it a marbled appearance. The mycelium on the bottom of the flask was about the same color as the spore masses.

Endothia radicalis.—Cultures 1 week old showed a loose, fluffy, erect mycelium covering nearly the whole surface of the mycelium. This was deep chrome to light orange yellow at the point of inoculation, passing through perilla purple and light pinkish lilac and fading into white at the margin. The mycelium had penetrated to the bottom of the flask, producing a sort of mosaic of colors. Where the rice grains came in contact with the glass they were perilla purple, and in the interstices the mycelium varied from apricot yellow to white. No spore masses were present.

The same species 1 month old gave a surface growth rather thick and abundant, much more compact than in the younger cultures, and ranging from buff yellow to white. The medium in contact with the glass was marbled, the deepest color being corinthian purple and the lightest ecru drab.

Endothia radicalis mississippiensis.—In cultures 1 week old the mycelium covered the whole surface of the medium. The aerial growth was erect, fluffy, much less in quantity than in *Endothia radicalis* and very similar to *E. parasitica* in character. The color was the same as in *E. parasitica* but more extensive. The medium was unchanged in appearance and no spore masses were seen.

The same fungus at the age of 1 month showed a thick, rather compact growth, somewhat more dense than in *Endothia radicalis* of the same age. The color of the mycelium on the surface was cadmium orange, changing to xanthine orange where in contact with the glass. The spore masses were minute, rather numerous, and of a pale yellow ochre color. The medium at the bottom first showed perilla purple when the cultures were 20 days old.

Endothia gyrosa.—Cultures from mycelium when 1 week old covered the whole surface of the medium. The growth was very thin, loose, and fluffy, pure white except at the point of inoculation and where in contact with the glass. At these points it was a light ochraceous buff with a faint suggestion of purplish lilac. The color of the medium was unchanged and no spores were produced.

The same fungus when 1 month old showed an abundant thick growth with a cottony tomentose pulvinate surface. The surface mycelium was capucine yellow, changing to xanthine orange where in contact with the glass. The color of the medium was marbled, ranging from lumiere green to apple green. The line marking the boundary between the mycelium and the culture medium on the sides of the flask was sooty black. No spores were found.

CULTURES ON CORN MEAL.

Endothia parasitica.—In cultures 1 week old the growth on corn meal covered about one-half of the surface of the medium. The outer margin was pure white, the remainder buff yellow below, with a superficial white growth above and the medium uncolored. A few small pustules with spore masses occurred near the point of inoculation.

Cultures 1 month old showed a compact growth nearly smooth on the surface. The superficial mycelium was pale orange yellow. The pale yellow ochre spore masses were minute, very numerous, and nearly covered the surface. The medium was slightly greenish about the sides of the flask just beneath the mycelium.

Endothia radicalis.—Cultures at the age of 1 week showed a growth of loose, fluffy mycelium covering one-half the surface of the medium. The growth was less in quantity and also less compact than that on rice and oatmeal. The same colors were present as in the cultures on rice, but paler. No spores were present.

Cultures 1 month old showed a compact growth with a nearly smooth surface. The color ranged from light cadmium to empire yellow. The whole mass of the medium was perilla purple. No spore masses were found.

Endothia radicalis mississippiensis.—Cultures 1 week old showed a growth very similar to that on oatmeal, but less in extent and in aerial development. The color of the mycelium was orange chrome. There was no discoloration of the medium, and no spore masses were found.

The same form of the fungus from the same source 1 month old produced a growth with a compact, rather uniform surface, the superficial portion having a coarse, matted, webby appearance, which was most noticeable about the margin. The color of the mycelium was cadmium orange to xanthine orange, while that of the medium was unchanged. Spore masses were much more numerous than in *Endothia radicalis*, but smaller and less numerous, though very similar to those of *E. parasitica*.

Endothia gyrosa.—Mycelial cultures 1 week old showed a growth practically the same in quantity as in *Endothia radicalis* but more compact on the surface and ochraceous buff near the point of inoculation, shading into white at the margin. There was no discoloration of the medium, and no spore masses were seen.

Cultures of the same kind 1 month old showed an abundant, rather thick growth, having the surface mostly covered with somewhat irregular tubercular masses of mycelium, suggesting immature pycnidial stromata similar to those formed in *Endothia radicalis*, but smaller and producing no spores. The surface of the culture was capucine buff. The surface of the tubercles was honey yellow to Isabella. The dark color was apparently due in part to numerous superficial water drops. A portion of the medium was perilla purple.

Aside from the differences in color, the most conspicuous and important characteristic of these fungi in corn-meal cultures is found in the fructification. Clinton has already mentioned and illustrated similar differences in cultures of these organisms on agar in Petri dishes. In *Endothia parasitica* the pycnidia and spore masses are small, numerous, thickly scattered, and embedded in the mycelium. *E. radicalis*, on the other hand, forms but few large, erumpent stro-

mata, with spores extruding in thick, elongated masses. *E. radicalis mississippiensis* appears somewhat intermediate between *E. parasitica* and *E. radicalis* in regard to the character and abundance of the pycnidia and in color of the growth. These peculiarities have been very uniform and constant in all the cultures on this medium, and if they could be coordinated with regular morphological differences in nature would justify its separation as a species.

SUMMARY.

The chestnut-blight fungus *Endothia parasitica* has three rather close relatives, *E. radicalis* (*E. virginiana* And. and And.), *E. radicalis mississippiensis*, and *E. gyrosa* (*E. radicalis* of Clinton), which in their pycnidial condition are not readily distinguished with certainty by either macroscopic or microscopic examination.

Physiological studies of these organisms in pure cultures have been made to test their relation to light, moisture, and temperature, and also their behavior on different culture media. All behaved the same in light and darkness, growing about equally well in either.

Cultures of *Endothia parasitica* and *E. radicalis* were made on corn meal to which different quantities of water had been added. The cultures with equal quantities of corn meal and water produced pycnidia and spores more abundantly than those to which the greater quantities of water were added.

Temperature tests showed that 8° to 9° C. is the least temperature at which any of the three species will grow. The highest temperature at which growth occurred was 35° C. for *Endothia parasitica* and *E. gyrosa*, and 32° C. for *E. radicalis*. The best temperature for growth was between 18° and 28° C. for all.

Studies of over 2,000 pure cultures of these fungi appear to show that they possess constant and easily recognized cultural characters on several culture media, of which potato agar and corn meal are the best that have been tried.

The most distinctive and reliable cultural character of *Endothia parasitica* is the peculiar, granular, glistening light orange-colored surface growth produced at the bottom of potato-agar slants. This usually appears within a week. None of the other organisms have developed this character, though *E. radicalis* occasionally in very old cultures shows suggestions of it. The orange color of the mycelium of *E. parasitica* as seen by transmitted light usually appears in three or four days, and this is ordinarily sufficient for identification. In the other species this color is not produced at all, or in case of *E. radicalis* not until a few days later.

On corn meal *Endothia parasitica* was constantly characterized by the early production of numerous small pycnidia and the want of any distinct color changes in the medium, while in *E. radicalis* the pycnidia are few and large, appearing later, and the medium becomes perilla purple. In *E. radicalis mississippiensis* the pycnidia are larger and less numerous than in *E. parasitica* and the color of the mycelium is orange chrome at the end of a week. *E. gyrosa* is distinguished from *E. parasitica* by its very tardy spore production and the formation of elevated or subcolumnar pycnidial stromata.

[Cir. 131]

MEASURING HAY IN RICKS OR STACKS.¹

By H. B. MC CLURE, *Agriculturist*, W. J. SPILLMAN, *Agriculturist in Charge*, and
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INTRODUCTION.

The methods presented here for determining the number of tons of hay in a rick or stack are in no way official. They simply represent the results of a somewhat extended investigation of the subject covering a period of several years. It is believed, however, that the method here presented for determining the number of cubic feet in a rick or stack of hay is quite accurate. The formulas given should be considered merely as the nearest approach we are able to make with our present knowledge.

THE PROBLEM OF MEASURING HAYRICKS.

The problem of obtaining an accurate formula for determining the number of cubic feet in a hayrick is difficult because of the variation in the shape of ricks. Even if the number of cubic feet in a rick is known, the problem of converting this into tons is difficult because of the wide variation in the compactness of hay in bulk.

The study of this subject was begun in the old Office of Grass and Forage-Plant Investigations, from which the Office of Farm Management developed. The actual number of cubic feet in a ton of hay in ricks has been measured in 92 cases. The results are very variable and show that any general rule for determining the weight of hay in a rick by measurement must be only an approximation. But thousands of tons of hay are sold annually on such measurements, and therefore it is desirable to establish at least average values for the quantities concerned in these measurements.

MEASURING THE VOLUME OF A HAYRICK.

The volume of a rick is equal to its length multiplied by its cross section. The length is easily measured. Let us consider the principles involved in measuring the area of the cross section. If the top of the rick were perfectly flat and the two sides straight up and

¹ Issued July 5, 1913.

down, the area of the cross section would simply be the width multiplied by the height. If the rick were triangular in cross section, so that the sides represented straight lines from the top of the rick to the bottom on each side, the area of the cross section would be one-half of the product of the base and the height. The actual area of the cross section lies somewhere between these two.

It is difficult to measure accurately the height of a rick. It is much easier to measure the "over," which is the distance from the ground on one side of the rick over the top of the rick to the ground on the other side. The length of the over depends upon three things: (1) Width, (2) height, and (3) "fullness" of the rick. The over is always somewhat more than twice the height.

It has been found by actual measurement that the cross section of a rick is the product of the over and the width, multiplied by a fraction varying from 0.25 to 0.37 (average value, 0.31), depending upon the height and fullness of the rick. If the rick is low in comparison with its width and nearly triangular in outline—that is, its sides are not very full—the fraction is small (0.25). If the rick is tall in comparison with its width, and the sides are very full, so that the top is well rounded, the fraction is large (0.37). Representing this fraction by F , the over by O , the width by W , and the length of the rick by L , the volume being represented by V , we have the following formula for determining the number of cubic feet in a rick:

$$V = F O W L.$$

The fact that the right-hand member of this formula spells the word "fowl" makes it easy to remember.

Figure 1 shows the cross sections of hayricks of nine different shapes, the corresponding value of the fraction F for each of these shapes being inserted in the outline of each cross section. The height of ricks Nos. 1, 4, and 7 (upper row) is three-fourths the width. The height of ricks Nos. 2, 5, and 8 (middle row) is equal to the width, while the height of ricks Nos. 3, 6, and 9 (lower row) is one and one-fourth times the width. Ricks Nos. 1, 2, and 3 (left column) are narrow or nearly triangular in outline; ricks Nos. 4, 5, and 6 (middle column) are medium full, while ricks Nos. 7, 8, and 9 (right column) are full and rounded. It will be noticed that the value of F is the same (0.31) in Nos. 3, 5, and 7; in Nos. 2 and 4 it is 0.28; and in Nos. 6 and 8, 0.34.

In attempting to find the volume of hayricks the choice between these various values of F may be found by comparing the shape of the end of the rick—that is, the cross section of the rick—with ricks Nos. 1 to 9 in figure 1. If the shape of the rick to be measured is intermediate between those shown in figure 1, intermediate values

of F may be used. The use of the above formula may be made clear by a few examples:

Example 1.—A hayrick is 16 feet wide, 24 feet long, and the over is 31.2 feet. The end view indicates that the shape of the rick is very close to No. 4 in figure 1. What is the volume of the rick?

Solution: $V=0.28 \times 31.2 \times 16 \times 24=3,354.6$ cubic feet.

Example 2.—A hayrick is 14 feet wide, 20 feet long, and the over is 34.2 feet. Inspection of the end of the rick shows that it is of the type of No. 8 in figure 1. What is the volume of the rick?

Solution: $V=0.34 \times 34.2 \times 14 \times 20=3,255.8$ cubic feet.

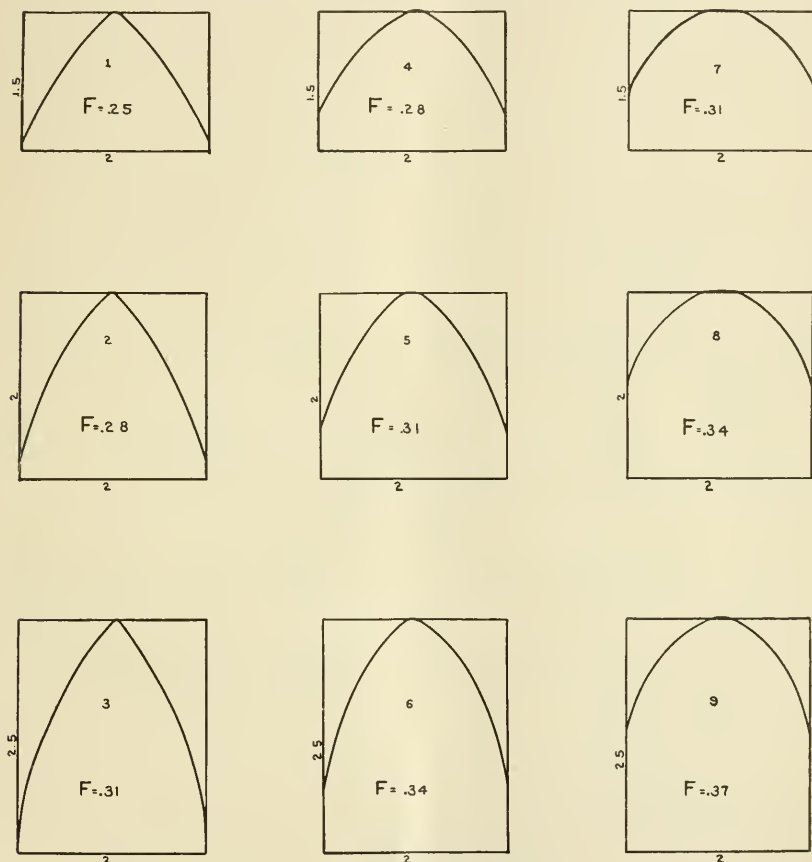


FIG. 1.—Cross sections of hayricks of different shapes.

MEASURING ROUND HAYSTACKS.

The measurement of the number of cubic feet in a round stack of hay is more difficult than it is for a rick. Simple formulas for this can be developed, however, by considering the round stack in two parts. The lower part is usually cylindrical, or in some cases drawn in at the bottom so as to present in outline the appearance

of a large pan, narrower at the bottom than at the top. The upper part varies in outline from a cone at one extreme to half a sphere at the other. The upper row of outlines in figure 2 represents these two extreme forms of top and a form intermediate between them. The lower row of outlines in figure 2 represents the two common shapes of the bottom part of round haystacks. It is necessary to calculate the volume of the top and bottom parts separately and then add them together.

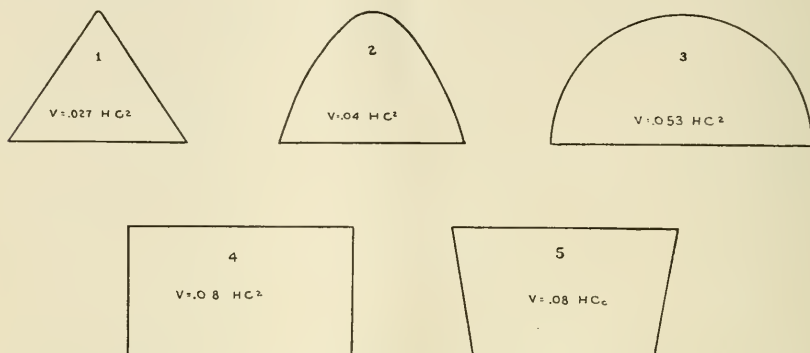


FIG. 2.—Diagram showing various shapes of round haystacks: 1, 2, and 3, Upper part of stacks (above the bulge); 4 and 5, lower part of stacks (below the bulge). Formulas for calculating the volume are given in each figure.

Formulas¹ for making these calculations are given on the outline drawings in figure 2. Thus, in drawing No. 1, the formula for finding the volume of a perfectly conical top is—

$$V = 0.027 HC^2.$$

In these formulas H represents the height of that portion of the stack being measured (not the full height of the stack), while C represents the circumference of the bottom portion of the top—that is, the circumference at the bulge or shoulder of the stack—and the small superior figure “2” to the right of C indicates that this circumference is to be squared.² The formulas for outlines Nos. 2, 3, and 4

¹ The method of deriving the formulas for determining the volume of round haystacks will be apparent from the following equations, $\pi = 3.1416$:

Solid.	Volume.
Cone.....	$\frac{1}{3}\pi R^2 H = 0.027 HC^2.$
Paraboloid.....	$\frac{1}{4}\pi R^2 H = 0.040 HC^2.$
Spheroid.....	$\frac{3}{8}\pi R^3 = 0.053 HC^2.$
Cylinder.....	$\pi R^2 H = 0.080 HC^2.$
Frustrum.....	$H\sqrt{\pi R^2 \pi r^2} = 0.080 HC^2.$

² This formula is obtained as follows:

$$V = \frac{1}{2} \sqrt{\frac{1}{R} - \frac{1}{\sqrt{H^2}}} V = 0.08 HC^2.$$

need no further explanation. The use of these formulas will be indicated below.

The formula for drawing No. 5 in figure 2 ($V=0.08 H C c$) means that the volume of the lower part (from the shoulder, or bulge, down) of a round stack shaped like the drawing is equal to 0.08 multiplied by the height of the base, this total multiplied by the circumference at the top of the base, and the product then multiplied by the circumference at the bottom of the stack.

In determining the volume of the tops of stacks it will be noticed that the decimal preceding the H in each of the formulas varies with the shape of the top. In order to use this formula in any given case, it will be necessary to determine by inspection what decimal to use. It will lie somewhere between 0.027 and 0.053. In measuring the volume of the base of the stack no such uncertainty exists, since the decimal in the formula is the same in all cases.

A few examples will illustrate the use of these formulas.

Example 1.—The base of a haystack is cylindrical and the top conical. The height of the base is 4 feet and the height of the top is 6 feet, the circumference of the stack at the ground and at the shoulder being 28 feet. What is the volume of the stack in cubic feet?

Solution:

Top of haystack..... $V=0.027 \times 6 \times 28^2 = 127.0$ cubic feet.

Bottom of haystack..... $V=0.08 \times 4 \times 28^2 = 250.9$ cubic feet.

Total..... 377.9 cubic feet.

Example 2.—A haystack has a top similar in shape to outline No. 2 in figure 2 and the base of the shape of outline No. 5 in figure 2. The height of the top is 5 feet, the circumference at the bulge is 26 feet, the height of the base is $3\frac{1}{2}$ feet, and the circumference at the bottom of the stack is 20 feet. What is the volume of the stack in cubic feet?

Solution:

Top of haystack..... $V=0.04 \times 5 \times 26^2 = 95.2$ cubic feet.

Bottom of haystack..... $V=0.08 \times 3\frac{1}{2} \times 26 \times 20 = 89.6$ cubic feet.

Total..... 184.8 cubic feet.

MEASURING THE HEIGHT OF HAYSTACKS.

The formula given for determining the number of cubic feet in a stack of hay involves the height of the stack, which it is necessary to measure in some manner. It is also desirable sometimes to measure the height of a rick. Figure 3 shows a simple method of accomplishing this. In using this method two points are marked on the ground on opposite sides of the rick or stack and at as nearly equal distances from its center as possible. A cord is then thrown

over the stack, stretched gently from the point *A* over the top of the stack to the point *B* and marked to show its length from *A* to *B*. The cord is then removed and placed on the ground in the position of *A'*, *B'*, and *T'*, the points *A'* and *B'* being exactly the same distance apart as *A* and *B*. At *T'* the cord should be made to assume the shape of that portion of the top of the stack with which the cord was in contact when it was stretched over the top of the stack. The distance *C' T'* will then be the height of the stack.

The distance *C' T'* will then be the height of the stack.

NUMBER OF CUBIC FEET IN A TON OF HAY.

The following figures show the number of cubic feet in a ton of hay, based on a number of measurements, as indicated below, the hay being mainly timothy or a mixture of clover and timothy in which timothy predominated.

The average number of cubic feet per ton of hay in 55 stacks

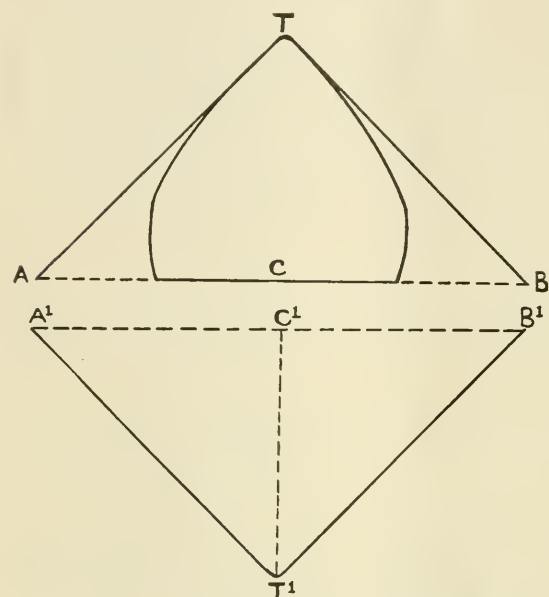


FIG. 3.—Diagram showing a method of measuring the height of stacks or ricks of hay.

which had been standing less than 30 days was 589.6; for 30 stacks which had been standing from 30 to 60 days the average number of cubic feet per ton was 581.5, while the average for 7 stacks which had been standing from 74 to 155 days was 514.9 cubic feet per ton.

Definite measurements of other kinds of hay have not been made. The data given were obtained in the States of Virginia and New York by measuring the volume of stacks and then weighing the hay as it was baled from the stack.

CELLULOSE AS A SOURCE OF ENERGY FOR NITROGEN FIXATION.¹

By I. G. McBeth, *Physiologist, Soil-Bacteriology and Plant-Nutrition Investigations.*

INTRODUCTION.

The great chemical principle underlying nitrogen fixation by micro-organisms which was early insisted upon by Berthelot and Winogradsky is that energy in the form of organic carbon is necessary for the fixation of gaseous nitrogen by the protoplasm of the bacterial cell. Subsequent investigations have indicated that from 100 to 200 units of carbonaceous substance are utilized in the fixation of 1 unit of nitrogen; therefore, the quantity of carbonaceous material in the soil becomes an exceedingly important factor in determining its nitrogen fixing power. Within the last decade much research has been undertaken to determine the kind of carbonaceous substances best adapted to serve as a source of energy for nitrogen-fixing bacteria. These investigations have shown that a great number of compounds may be utilized either directly or indirectly by these organisms, but the nature of the compounds of greatest importance in the soil is still somewhat problematical. It seems certain, however, that the source of energy for nitrogen fixation in soils must be derived from the decomposing plant substances, and as by far the larger part of the organic carbon added to the soil as roots, stubble, etc., is in the form of cellulose, it would seem that this substance may have a far reaching effect on the development of nitrogen fixing organisms therein.

As cellulose is an inert compound inaccessible to such nitrogen-fixing bacteria as *Azotobacter* it would seem that its value as a source of energy for nitrogen fixation may, in a measure at least, be dependent upon the activity of other organisms capable of breaking it down into more accessible compounds. In studying the value of these compounds as a source of energy for *Azotobacter* it seems desirable to grow the cellulose destroying and nitrogen fixing organisms in association, or at least in the same nutrient solution. In such an experiment it is obvious that the solution employed must be favorable for the process of nitrogen fixation as well as for cellulose destruction.

¹ Issued July 5, 1913.

Our studies of the cellulose destroying bacteria have shown that these organisms bring about a rapid destruction of cellulose only when supplied with a considerable quantity of combined nitrogen. It therefore seemed necessary to consider first the effect of combined nitrogen in the culture media on the nitrogen fixing power of *Azotobacter* before undertaking to determine the value of cellulose as an indirect source of energy for nitrogen fixation by these organisms.

REVIEW OF INVESTIGATIONS ON THE EFFECT OF COMBINED NITROGEN IN THE CULTURE MEDIA ON THE NITROGEN-FIXING PROPERTIES OF MICRO-ORGANISMS.¹

The synthetic culture media used by different investigators in the study of the nitrogen-fixing properties of micro-organisms, although showing considerable variety in composition, have usually contained little or no combined nitrogen. The absence of nitrogen in these media seems to have resulted from a very general acceptance of the early conclusions of Berthelot and Winogradsky that if an organism is grown in a medium rich in combined nitrogen there is a reduction or total loss of the nitrogen-fixing power exhibited by the organism when grown in nitrogen free media. From a review of the work of these early investigators it would seem that the results secured would hardly warrant a final acceptance of their views without additional proof.

Studies by Berthelot of nitrogen fixation with pure cultures are limited, and in these studies no special attention was given to the effect of combined nitrogen on the nitrogen-fixing power of the organisms. Berthelot believed, however, that a small quantity of combined nitrogen was required to give the organisms the minimum amount of energy necessary to enable them to utilize the free nitrogen of the air.

Winogradsky soon proved this latter conclusion to be erroneous by demonstrating the nitrogen-fixing power of an impure culture of a butyric ferment in nutrient solutions from which the last trace of nitrogen had been removed. In 13 flasks containing no nitrogen he secured a fixation of from 1.25 to 3 milligrams of nitrogen for each gram of dextrose added. When 2.1 milligrams of combined nitrogen were added to the solution, the fixation for four flasks varied from 2.1 to 3.56 milligrams for each gram of dextrose added. With three flasks in which 3, 3.3, and 4 milligrams of combined nitrogen were added the fixation was 2.5, 0.3, and 0.4 milligrams, respectively. It would seem that the addition of 2.1 milligrams of combined nitrogen had a slight stimulating effect on the nitrogen-fixing organisms, while the addition of larger quantities reduced the quantity of nitrogen fixed.

¹ For bibliography, see p. 34.

The following year Winogradsky continued his studies of the effect of combined nitrogen upon the nitrogen-fixing properties of this butyric ferment associated with two other organisms. In one series of flasks in which the nutrient solutions contained 3 grams of dextrose and quantities of nitrogen as ammonium sulphate varying from 2.1 to 21.2 milligrams the results showed the greatest gain for the flask receiving the smallest quantity of combined nitrogen, and when the combined nitrogen added amounted to 21.2 milligrams there was a loss of 2.2 milligrams. Winogradsky therefore concluded that for nitrogen fixation the ratio of nitrogen to carbohydrate should not be greater than 6 to 1,000. We should not lose sight of the fact, however, that the results secured by Winogradsky in this experiment may have been determined in a large measure by the impurity of his culture.

Work by Ashby and by Hoffmann and Hammer has indicated that a large percentage of the nitrogen fixed by impure cultures in solutions may be lost through denitrifying processes, especially if the incubation period is prolonged. The latter investigators noted a loss of 38 per cent of the nitrogen fixed in a series of flasks incubated for six weeks. In view of these results it would seem that the gains secured by Winogradsky are of somewhat doubtful value in determining the effect of combined nitrogen on the nitrogen-fixing power of micro-organisms.

In 1897 Mazé reported nitrogen-fixation studies with *Bacillus radicicola* in a decoction of white kidney bean to which 2.6 per cent of saccharose, a little sodium chlorid, and a trace of sodium bicarbonate were added. One hundred cubic centimeters of the solution contained 22.4 milligrams of initial nitrogen. However, a total gain of 23.4 milligrams of nitrogen was secured, or a gain of 9 milligrams for each gram of sugar added. The nitrogen gain reported in this rich nitrogenous medium is far in excess of gains reported by later investigators for *B. radicicola* in solutions weak in initial nitrogen.

Saida in 1901 studied the nitrogen-fixing properties of *Phoma betae*, *Mucor stolonifer*, and *Aspergillus niger* in nitrogen-free and nitrogen-containing solutions. The nitrogen fixation by these organisms was usually stimulated by the addition of small quantities of combined nitrogen.

Lipman in 1903 studied the nitrogen-fixing properties of *Azotobacter vinelandii* in mannite solutions to which small quantities of nitrogen as potassium nitrate, ammonium chlorid, and peptone were added. The gains secured did not show any appreciable effect from any of the nitrogen compounds employed. However, the quantities of nitrogen added were extremely small, amounting to less than 1 milligram to each 100 cubic centimeters of solution.

In 1904 Moore in nitrogen-fixation studies with *Bacillus radiclecola* in nutrient solutions secured a fixation of 0.2 to 2.2 milligrams for each 100 cubic centimeters of nitrogen-free solution. When 0.01 per cent of ammonium phosphate was added the gains sometimes amounted to 3.1 milligrams to each 100 cubic centimeters of solution.

Stoklasa in 1908 secured the following results with a solution containing 2 per cent of mannite and 0.2 per cent of sodium nitrate held under aerobic conditions at 20° C. and inoculated with *Azotobacter chroococcum*:

Nitrogen in form of—	Milligrams of nitrogen in inoculated flasks.			Milligrams of nitrate nitrogen in sterile flasks.
	10 days.	20 days.	30 days.	
Ammonia.....	14.8	24.3	28.8	326.2
Nitrite.....	222.6	243.5	242.1	336.2
Nitrate.....	32.4	14.4	12.0	.....
Organic.....	64.8	60.5	65.2	.....
Total.....	334.6	342.7	348.1	.....

From this experiment Stoklasa concluded that *Azotobacter* does not assimilate free nitrogen in the presence of nitrate. It would seem, however, that there was a slight gain in nitrogen, as the inoculated flasks in every test show an increase over the average of the two sterile flasks, though the gains indicated are possibly within experimental error.

Bacillus radiobacter under similar conditions was found to be a violent denitrifier, liberating in 10 days 76.3 per cent of the nitrate added.

Bredemann in 1909 in studying the nitrogen-fixing properties of *Clostridium pasteurianum* and *Bacillus amylobacter* in peptone-dextrose solutions secured the following results:

Organism.	Quantity of solution employed.	Peptone nitrogen added.	Nitrogen gained.	Nitrogen gained per gram of dextrose employed.
	Cubic centimeters.	Milligrams.	Milligrams.	Milligrams.
<i>Clostridium pasteurianum</i>	500	1.600 7.983 39.915	20.656 18.423 17.031	2.07 1.84 1.70
<i>Bacillus amylobacter</i>	500	1.600 7.983 39.915 79.825	22.656 14.583 16.871 10.731	6.02 3.24 4.22 2.75

In another table Bredemann shows the nitrogen-fixing power of *Clostridium pasteurianum* in dextrose solutions to which no combined nitrogen was added as varying from 0.8 to 1.3 milligrams to each gram of dextrose consumed; *Bacillus amylobacter* in a similar solu-

tion gave 0.7 to 2.84 milligrams to each gram of dextrose used. It would appear, therefore, that comparatively large quantities of peptone had a stimulating effect on the nitrogen-fixing properties of *Clostridium pasteurianum* and *Bacillus amylobacter*.

In 1909 Latham secured unusually high fixation with *Aspergillus niger* in nutrient solutions containing from 115.4 to 156.3 milligrams of nitrogen as ammonium nitrate for each 50 cubic centimeters of solution; however, when the nitrogen added amounted to 160.3 milligrams to each 50 cubic centimeters of solution there was a loss of nitrogen. Latham concludes that the critical point with regard to the nitrogen supply for *Aspergillus niger* is slightly below 160.3 milligrams to 50 cubic centimeters of solution. The percentage of nitrogen added to these solutions is much greater than the total percentage found in soils or in most plant tissues, and yet the nitrogen gains secured are very high for this organism.

Stahel in 1911 in studying the nitrogen-fixing power of various molds in nitrogen-free and nitrogen-containing solutions secured a decided stimulating effect by the addition of nitrogen as potassium nitrate in quantities from 0.002 to 0.016 per cent.

After a somewhat careful review of the literature bearing upon the effect of combined nitrogen on the nitrogen-fixing power of microorganisms it seems to the writer that there are not sufficient data to show that the presence of considerable quantities of combined nitrogen in the culture media reduces or destroys the nitrogen-fixing properties of organisms which show a pronounced nitrogen-fixing power in nitrogen-free solutions. On the contrary, the data obtainable seem to indicate that the nitrogen-fixing power of some organisms may be greatly stimulated by the addition of nitrogen to the culture medium.

EFFECT OF AMMONIUM SULPHATE UPON THE NITROGEN-FIXING POWER OF AZOTOBACTER CHROOCOCCUM AND AZOTOBACTER BEIJERINCKII IN NUTRIENT SOLUTIONS.

The nutrient solution employed in this experiment was prepared according to the formula recommended by Ashby, except that 15 grams of mannite to the liter were added. After a thorough mixing the solution was divided into two equal parts; one portion then received an addition of 1 gram of ammonium sulphate to the liter. The solutions were distributed in 1-liter Erlenmeyer flasks, 200 cubic centimeters being placed in each flask. After sterilization, two flasks from each lot of solution were reserved for initial nitrogen and the remaining solutions inoculated with *Azotobacter chroococcum* or *A. beijerinckii* and incubated for 18 days at 30° C. The results are shown in Table I.¹

¹ The nitrogen determinations included in this and in the following tables were made by Dr. T. C. Trescott, of the Bureau of Chemistry, U. S. Department of Agriculture.

TABLE I.—*Effect of ammonium sulphate upon the nitrogen-fixing power of Azotobacter chroococcum and A. beijerinckii in nutrient solutions.*

Quantity of nitrogen (in milligrams) in 200 c. c. solutions.				Quantity of nitrogen (in milligrams) gained in each 200 c. c. of solution.	
At beginning of experiment.		After 18 days' incubation.			
Percentage of ammonium sulphate added.		Percentage of ammonium sulphate added.		Percentage of ammonium sulphate added.	
0	0.1	0	0.1	0	0.1

INOCULATED WITH AZOTOBACTER CHROOCOCCUM.

0.56	41.54	2.25	44.07	1.69	2.61
.56	41.38	3.37	44.91	2.81	3.45
-----		2.25	45.19	1.69	3.73
-----		3.37	44.35	2.81	2.89
Average... .56	41.46	2.81	44.63	2.25	3.17

INOCULATED WITH AZOTOBACTER BEIJERINCKII.

0.56	41.54	3.37	44.35	2.81	2.89
.56	41.38	Lost.	44.91	-----	3.45
-----		3.09	45.47	2.53	4.01
-----		2.80	Lost.	2.24	-----
Average... .56	41.46	3.09	44.91	2.53	3.45

At the conclusion of the incubation period the solutions were tested for mannite and found to contain a considerable portion of the 1.5 per cent added, but as no accurate determination of the quantity of mannite remaining in the solution was made the gain in nitrogen can not be calculated for each gram of mannite consumed. The solutions to which ammonium sulphate was added were also tested for the presence of ammonia. The method employed was to remove a few drops of the solution by means of a pipette, dilute with 10 cubic centimeters of distilled water, and treat with Nessler's reagent. Strongly positive tests were secured in every instance, thus showing that a considerable portion of the ammonium sulphate added still remained in the solution at the end of the experiment.

The quantities of nitrogen fixed for both *Azotobacter chroococcum* and *A. beijerinckii* are rather low for these organisms; however, the results seem to indicate that *Azotobacter* species not only fix atmospheric nitrogen in the presence of an abundant supply of combined nitrogen in the form of ammonium sulphate, but the presence of the combined nitrogen in the nutrient solution stimulates these organisms to greater activity, so that a larger quantity of atmospheric nitrogen is fixed than under conditions requiring the entire nitrogen supply to be drawn from the free nitrogen of the air.

NITROGEN FIXATION BY AZOTOBACTER ALONE AND IN ASSOCIATION WITH BACILLUS ROSSICA, WITH BOTH DEXTROSE AND CELLULOSE AS A SOURCE OF ENERGY.

Three nutrient solutions were employed in this experiment. The composition of these solutions is as follows:

Solution A.	Potassium phosphate, dibasic.....	gram..	1
	Magnesium sulphate.....	do....	1
	Sodium chlorid.....	do....	1
	Calcium carbonate.....	do....	2
	Dextrose.....	do....	10
	Cellulose.....	do....	1
	Tap water.....	c c..	1,000

Solution B. The same as solution A with the addition of 0.05 per cent of ammonium sulphate.

Solution C. The same as solution A with the addition of 0.1 per cent of ammonium sulphate.

The results of this experiment are shown in Table II.

TABLE II.—*Nitrogen fixation by Azotobacter alone and in association with Bacillus rossica, with both dextrose and cellulose as a source of energy.*

Solution employed.	Quantity of nitrogen (in milligrams) in 500 c. c. solution after 60 days' incubation at 30° C.			Quantity of nitrogen (in milligrams) gained in 500 c. c. nutrient solution.	
	Sterile.	A. chroococ- cum alone.	A. chroococ- cum+B. ros- sica.	A. chroococ- cum alone	A. chroococ- cum+B. ros- sica.
Solution A.....	30.60	34.53	39.30	4.59	9.36
	29.75	37.61	39.30	7.67	9.36
	29.47	37.33	37.05	7.39	7.11
	.....	37.61	31.75	7.67	1.81
Average.....	29.94	36.77	36.85	6.83	6.91
Solution B.....	56.70	60.63	76.91	3.08	19.36
	58.39	61.19	79.44	3.64	21.89
					
Average.....	57.55	60.91	78.18	3.36	20.63
Solution C.....	104.07	133.05	142.03	27.06	36.04
	119.58	133.05	143.16	27.06	37.17
	94.32	135.30	143.72	29.31	37.73
					
Average.....	105.99	133.80	142.97	27.81	36.98
	Sterile.	A. beijerinckii alone.	A. beijerinckii+B. rossica.	A. beijerinckii alone.	A. beijerinckii+B. rossica.
Solution C.....	104.07	133.33	140.07	27.34	34.08
	119.58	135.86	141.47	29.87	35.48
	94.32	133.89	143.16	27.90	37.17
Average.....	105.99	134.36	141.57	28.37	35.58

Considering, first, the results of *Azotobacter chroococcum* alone it is seen that in the nutrient solution to which no combined nitrogen was added this organism gave an average gain of 6.83 milligrams for each 500 cubic centimeters of solution. In solution B the nitrogen gained amounted to but 3.36 milligrams, which is less than half the gain shown by this organism in solution A: however, since the gain for *A. chroococcum* in solution C is almost four times as great as in solution

As it would seem that the low gains secured in solution B are due to causes other than the addition of 0.05 per cent of ammonium sulphate.

The average gain for *Azotobacter chroococcum* and *Bacillus rossica* in solution A is but little higher than for *Azotobacter* alone, and it is believed that the gains in either case came largely, if not entirely, from the dextrose, as *B. rossica* appeared to be unable to attack the cellulose in this solution, or if the cellulose was attacked the action was so slow that no destruction of the paper could be observed after 60 days' incubation. When 0.05 per cent of ammonium sulphate was added to the nutrient solution, a partial destruction of the paper occurred, and it is observed that the nitrogen gains in these solutions are much higher than for those in which no destruction of cellulose could be detected. In solution C, which contained 0.1 per cent of ammonium sulphate, an almost complete destruction of cellulose took place, and it is seen that the nitrogen gains are consistently higher than for either solution A or B. The results secured with *A. beijerinckii* in solution C are not materially different from those secured with *A. chroococcum* in this solution.

TABLE III.—*Nitrogen fixation by mixed cultures of Azotobacter and cellulose-destroying bacteria, with cellulose as a source of energy.*

Quantity of nitrogen (in milligrams) in 500 c. c. solution ¹ after 84 days' incubation at 30° C.			Quantity of nitrogen (in milligrams) gained in 500 c. c. nutrient solution.	
Sterile.	<i>A. chroococcum</i> + <i>Bacillus rossica</i> .	<i>A. beijerinckii</i> + <i>Bacillus rossica</i> .	<i>A. chroococcum</i> + <i>Bacillus rossica</i> .	<i>A. beijerinckii</i> + <i>Bacillus rossica</i> .
92.35	101.89	102.74	8.00	8.85
94.03	104.42	103.86	10.53	9.97
94.03	101.89	103.30	8.00	9.41
95.16	101.61	102.74	7.72	8.85
.....	101.89	102.17	8.00	8.28
.....	101.89	102.17	8.00	8.28
.....	102.74	103.02	8.85	9.13
Average... 93.89	102.33	102.86	8.44	8.97

Sterile.	<i>A. chroococcum</i> + <i>Bacterium fimi</i> .	<i>A. beijerinckii</i> + <i>Bacterium fimi</i> .	<i>A. chroococcum</i> + <i>Bacterium fimi</i> .	<i>A. beijerinckii</i> + <i>Bacterium fimi</i> .
95.16	104.70	104.42	11.69	11.41
91.51	103.30	103.58	10.29	10.57
92.35	104.14	104.14	11.13	11.13
.....	104.14	104.14	11.13	11.13
.....	104.14	104.14	11.13	11.13
Average... 93.01	104.08	104.08	11.07	11.07

Sterile.	<i>A. chroococcum</i> + <i>Bacterium flavigena</i> .	<i>A. beijerinckii</i> + <i>Bacterium flavigena</i> .	<i>A. chroococcum</i> + <i>Bacterium flavigena</i> .	<i>A. beijerinckii</i> + <i>Bacterium flavigena</i> .
95.16	102.74	103.30	9.73	10.29
91.51	103.58	104.42	10.57	11.41
92.35	104.14	103.30	11.13	10.29
.....	103.29	103.30	10.28	10.29
Average... 93.01	103.44	103.58	10.43	10.57

¹ The nutrient solution employed in this experiment is the same as solution C, Table II, except that it contained no dextrose.

The table shows that the solutions containing *Azotobacter chroococcum* and *Bacillus rossica* fixed 8.44 milligrams of nitrogen on the average for each 500 cubic centimeters of solution, while the average quantity fixed by *A. beijerinckii* and *B. rossica* was but little higher. The 1 gram of filter paper added to these solutions was almost completely destroyed, so that the gains secured are for approximately 1 gram of cellulose.

The solutions inoculated with *Bacterium fimi* as the cellulose-destroying organism show gains somewhat higher than those secured from the solution containing *Bacillus rossica* as the cellulose destroyer, although much more of the cellulose remained undissolved in the solutions containing *Bacterium fimi*. It would therefore appear that the products formed by *Bacterium fimi* may be of greater value in stimulating the nitrogen-fixing properties of *Azotobacter* than those formed by *Bacillus rossica*.

The nitrogen gains in the solution containing *Bacterium flavigena* and *Azotobacter chroococcum* or *A. beijerinckii* are also higher than the gains secured in the *Bacillus rossica* series and but little lower than the gains in the *Bacterium fimi* series. Only a part of the cellulose added was dissolved, so that the gains can not be estimated for each gram of cellulose consumed.

CONCLUSIONS.

The addition of 0.1 per cent of ammonium sulphate to the nutrient solution stimulated the nitrogen-fixing power of *Azotobacter chroococcum* and *A. beijerinckii*.

Mixed cultures of *Bacillus rossica* and *Azotobacter chroococcum* in solutions containing both dextrose and cellulose as sources of energy gave decided gains over *Azotobacter* alone only when the solutions contained a considerable quantity of initial nitrogen and a destruction of the cellulose occurred.

Azotobacter chroococcum and *A. beijerinckii* in association with *Bacillus rossica*, *Bacterium fimi*, or *Bacterium flavigena* fixed quantities of nitrogen varying from 7.72 to 11.41 milligrams for each 500 cubic centimeters of solution containing cellulose only as a source of energy.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 132.

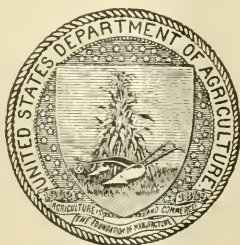
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MISCELLANEOUS PAPERS.

The Farmer's Income	W. J. SPILLMAN
Cotton Farming in the Southwest	O. F. COOK
Mosaic Coherence of Characters in Seeds of Maize	G. N. COLLINS

Issued July 19, 1913

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GOVERNMENT PRINTING OFFICE.

1913.

BUREAU OF PLANT INDUSTRY.

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[Cir. 132]

THE FARMER'S INCOME.¹

By W. J. SPILLMAN, *Agriculturist in Charge of the Office of Farm Management.*

INTRODUCTION.

It has never been possible to secure accurate data on the average income of American farmers. It happens, however, that the data collected in the census of 1910, combined with certain factors worked out in the experience of the Office of Farm Management in conducting farm-management surveys, render it possible to arrive at a sum which, if increased by two small unknown items and decreased by one rather large but unknown item, would represent the farmer's net income. The two additions probably do not balance the one deduction, so that the actual net income is almost certainly less than the sum given in Table I.

TABLE I.—*Labor income of farmers in the United States.*

Page. ²	Item.	Total.	Amount per farm.
263	Number of farms.....	6,361,502	138.1 acres. ³
269	Improved land..... acres..	478,451,750	75.2 acres.
276	Total farm investment.....	\$40,991,449,090	\$6,443.67.
277	Investment in farm buildings.....	\$6,325,451,528	\$994.33.
277	Investment in implements and machinery.....	\$1,265,149,783	\$198.88.

RECEIPTS.			
348	Dairy products (excluding milk and cream used at home).....	\$596,413,463	\$93.75
352	Wool.....	65,472,328	10.29
352	Mohair.....	901,597	.14
355	Eggs produced.....	306,688,960	48.21
355	Poultry raised.....	202,506,272	31.83
356	Honey and wax.....	5,992,083	.94
358	Domestic animals sold.....	1,562,936,694	245.69
358	Domestic animals slaughtered.....	270,238,793	42.48
370	Total value of all crops.....	\$5,487,161,223	
379	Corn.....	\$1,438,553,919	
383	Oats.....	414,697,422	
388	Barley.....	92,458,571	
397	Hay, etc.....	\$24,004,877	
	Total value of crops used for feeding.....	2,769,714,789	
373	Feed sold.....	509,253,522	
	Net value of crops fed.....	2,260,461,267	
	Net value of crops.....	3,226,699,956	507.22
	Total gross farm income.....	6,237,850,146	980.55

¹ Issued July 19, 1913.

² Abstract of the Thirteenth Census.

³ Average total area per farm.

TABLE I.—*Labor income of farmers in the United States—Continued.*

EXPENSES.

Page.	Item.	Total.	Amount per farm.
373	Labor.....	\$651,611,287	\$102.43
373	Fertilizers.....	114,882,541	18.06
373	Feed.....	299,839,857	47.13
	Maintenance of buildings (at 5 per cent) ¹	316,272,576	49.72
	Maintenance of implements and machinery (20 per cent).....	253,029,956	39.78
	Taxes (0.6 per cent).....	245,948,694	38.66
	Total.....	1,881,584,911	295.78
	Miscellaneous expenses (15 per cent of other expenses).....	282,237,736	44.37
	Total expenses.....	2,163,822,647	340.15

SUMMARY.

Total gross income.....	\$6,237,850,146	\$980.55
Total expenses.....	2,163,822,647	340.15
Net farm income.....	4,074,027,499	640.40
Interest on investment (at 5 per cent).....	2,049,572,454	322.18
Labor income ²	2,024,455,045	318.22
Interest on mortgage (\$1,715 at 6 per cent).....		102.90
Available for purchase of live stock and for family living.....		537.50

¹ 4½ per cent in New England, New York, Pennsylvania, Michigan, and Wisconsin; 5 per cent in Virginia, West Virginia, Illinois, Missouri, Kansas, Iowa, Nebraska, Minnesota, North Dakota, South Dakota, Ohio, and Indiana; 5½ per cent elsewhere.

² Includes unpaid family labor and all the farm furnishes toward the family living except milk and cream. Does not include income from outside sources, and the amount paid for live stock bought must be deducted from this sum.

The items of income about which no information is available are the value of the milk and cream consumed on the home farm and what the farmer earns for work outside his farm. In some regions this latter item is important. Thousands of farmers receive a large part of their income from labor done for others at times when they do not have profitable employment on their own farms. In other sections of the country this item is unimportant.

The item of expenditure about which no information is obtainable is the amount paid for the live stock purchased. This is a very important item in those sections of the country where the fattening of stock is practiced. It is also a considerable sum in dairy regions, but in regions where no live stock except work animals and a few head of miscellaneous stock are kept it is not very important.

It is probable that the average working life of a horse is from 8 to 10 years. The average depreciation on work horses would then be from about 12 per cent to 10 per cent annually. Where work horses are the only animals kept, the expenditures for the purchase of live stock would therefore probably not average more than \$15 or \$20 per year per animal. It is impossible to give even a rough estimate of their cost in regions where live stock represent an important farm enterprise. The data presented in the accompanying table should be interpreted in the light of these omissions.

THE AVERAGE FARM INVESTMENT.

The average area of the American farm in 1910 was 138.1 acres. Of this area 75.2 acres are classed as improved land. The average area devoted to crops is 49.77 acres. The total average investment per farm is \$6,443.67, the amount in farm buildings being \$994.33 and that in implements and machinery, \$198.88.

RECEIPTS.

The data for the receipts of the farmer are obtained entirely from the census returns. In this calculation the farm is credited with the total value of dairy products, wool, mohair, eggs and poultry, honey and wax, and domestic animals sold and slaughtered, with the exception of the milk and cream consumed on the farm where it is produced. This latter item is not given in the census returns. Whatever its value it should be added to the farm income.

The farm is also credited in Table I with the total value of all the crops produced except that part fed to live stock. This valuation is arrived at in the following manner:

The amount of corn, oats, barley, hay, and forage sold is deducted from the total value of these crops, it being assumed that the remainder is fed on the place and accounted for in the live-stock product listed earlier in the table. The value of that portion of these crops which is fed to live stock is then deducted from the total value of all the crops, the remainder being credited to the farm. The farm is thus credited with the butter, cheese, eggs, poultry, honey, meat, fruits, vegetables, bread, etc., consumed on the farm where it is produced, and the value of these products thus consumed on the farm is included in the farm income.

As stated already, any income the farmer may secure by work done outside his farm or from any other outside source is to be added to the net income given in Table I.

EXPENSES.

The only important item of expense not enumerated in the table is the sum expended annually in the purchase of live stock. Of the other expense items the amount for labor, fertilizers, and feed are given directly in the census returns.

The expense for the maintenance of buildings is placed at 5 per cent of the value of the buildings. This is only an estimate, but it is based on rather extensive investigations by the Office of Farm Management and is believed to be approximately correct.

The cost of maintenance, including repairs, of implements and machinery is placed at 20 per cent of their cash value. This estimate is based on extensive investigations by the Office of Farm

Management and agrees with the estimate in Warren's Farm Management. Taxes are assumed to be six-tenths of 1 per cent as an average for the whole country. This item will, of course, vary in different sections.

There are numerous other items of expense in the conduct of a farm. In a number of farm-management surveys conducted by the Office of Farm Management these remaining items have amounted on the average to about 15 per cent of other expenditures, and this is the factor assumed in the calculations here made. The total farm expenses, omitting the item of live stock purchased, are \$340.15.

THE FARM INCOME.

The farm income is obtained by deducting the total expenses from the total receipts, and amounts to \$640.40. If we assume 5 per cent as the rate of interest to which capital invested in agriculture is entitled, the farm income would then be distributed between interest and labor income as follows: Interest on investment, \$322.18, labor income, \$318.22.

Out of the farm income as here calculated, increased by outside earnings and by the value of milk and cream consumed on the home farm, the farmer must pay interest on his indebtedness, pay for any live stock purchased, and provide the living expenses of himself and family. The average farm mortgage in this country, based on the number of all farms, is \$1,715, which at 6 per cent per annum amounts to \$102.90. This amount deducted from the farm income of \$640.40 leaves \$537.50 (to which must be added the value of milk and cream consumed on the home farm and any income from outside sources) as the sum to be used in the purchase of live stock, in living expenses, and in savings.

In comparing the farmer's income with that of wage workers in any other industry it must be remembered that a majority of farmers are also capitalists. The interest on the farmer's capital thus constitutes a portion of this income, and this interest added to the small additional labor income he receives represents the sum available for his living. The labor income is undoubtedly smaller than it otherwise would be if the farmer did not also have the interest on his capital. Thus, we have found that in the better agricultural sections the labor income of tenants is considerably higher than that of farmers who work their own farms, although the latter have larger incomes than the tenants when we take into account the interest on their investment.

A very large percentage of American farmers live on the interest of their investment and do not receive anything for their own wages. Where the farm is of considerable size, such farmers are able to live

well, but on the small farm the interest on the investment is not sufficient to permit a high standard of living, so that the farmer must have some labor income in addition. The average income of the farmer could be increased by making the farms larger and thus reducing the number of individuals engaged in agricultural production. This could easily be done without decreasing production by better farm organization and the utilization of larger machinery and more power on the farm.

An average in itself has little meaning. In the present case, however, it is reasonable to infer that at least half of the farm families in this country have incomes smaller than those given in Table I. Individual farmers here and there have incomes larger than this average, but the facts presented in the table indicate that on the whole the income of farmers in this country, even when we include as a part of the income those things consumed on the farm where they are produced, is certainly not more than sufficient to pay 5 per cent on the investment and ordinary farm wages for the labor they do, and it is probably considerably less than this.

[Cir. 132]

COTTON FARMING IN THE SOUTHWEST.¹

By O. F. COOK, *Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.*

INTRODUCTION.

A new cotton industry is developing in the Southwestern States. Instead of extending, as formerly supposed, only to the middle of Texas, cotton culture now seems likely to become one of the chief agricultural resources of the whole region from the Rio Grande Valley in southern Texas through New Mexico and Arizona to the Imperial Valley of southern California.

The extension of cotton culture into the drier regions of the Southwest may be ascribed partly to the invasion of the former cotton belt by the boll weevil and partly to the fact that the southwestern conditions are really favorable for cotton culture. The drier climate not only affords protection against the boll weevil but against other dangers encountered in the Gulf States and along the Atlantic seaboard. The wilt and anthracnose diseases are often serious, and there are other insect enemies, such as the bollworm, the leaf worm, and the red spider, which sometimes destroy the crop quite as effectively as the boll weevil.

Another important consideration is that the harvest season in the Southwest is very long and usually quite rainless, so that the crop can be gathered without loss or injury from discoloration. Wet weather during the harvest season damages the eastern cotton crop every year to the extent of many millions of dollars. Little account is taken of such losses, because they are too frequent and familiar and are considered as ordinary accidents of farming.

It is no longer feared that the boll weevil will put an end to cotton culture in the Gulf and South Atlantic States, but the danger of weevil injury adds another element of uncertainty, so that the farmer can not rely upon cotton to any such extent as in the past. Other crops must be grown, and where these prove more profitable the planting of cotton is likely to decline or to cease altogether. Even in advance of the arrival of the boll weevil, cotton is losing ground in some districts because of other factors that render the crop uncertain.

While the production of cotton may not decline in the more eastern States to the same extent that it has in Louisiana, there is certainly no reason to expect any such increase of production as will be necessary to enable the United States to supply its usual quota of the world's ever-increasing demand. It is therefore a matter of special interest at the present time that a new cotton industry can be developed in the Southwest, in a region whose agricultural possibilities are still only slightly appreciated.

The agricultural occupation of the Southwest is only beginning, and many years are likely to elapse before its resources of cotton production can be realized. Farming is attended by unusual difficulties because the conditions are so unlike those of other parts of the United States. The environment is a new one, not only for the cotton plant but for the farmer, and a period of adaptation is necessary for both. The plant has received more attention thus far than the farmer, and it is this inequality that must now be removed if substantial progress is to be made. The possibilities of cotton culture mean nothing without a farming population to take advantage of them.

The most striking advantages of irrigation agriculture are to be expected in the Southwest because of the climatic conditions that enable crops to be grown through the whole 12 months of the year. But it is these same climatic conditions that render the agricultural problems of the Southwest so new and difficult. The wider range of temperature prevents any direct duplication of the results that have been secured from fruit farming in some parts of California, where the development of irrigation facilities has been followed by an immense increase in land values. Different crops and different methods of farming must be used if any similar success is to be obtained in the dry, interior regions. Cotton is one of these crops that can not be grown near the coast, but requires the warmer climate of the dry interior to bring it to normal maturity.

COTTON AS A FACTOR OF AGRICULTURAL DEVELOPMENT.

The progress of the southwestern region as a whole must depend obviously on the establishment of a series of agricultural industries, of which cotton seems likely to be one of the most important and one of the easiest to develop. Indeed, it is hardly too much to say that for many of the more isolated southwestern communities cotton now appears to be the only staple commercial crop that can be raised with a fair prospect of a remunerative cash return. And even in communities where transportation facilities exist, so that fruits or other perishable products can be sent to market, cotton is likely to become popular as one of the safest crops, if not the most profitable.

In southern Texas, as well as in Arizona and California, irrigation facilities have been provided largely with a view to other crops that have been considered more profitable than cotton. The present indications are that cotton will be recognized eventually as the chief agricultural resource of many enterprises that have been promoted on the basis of more speculative truck and fruit crops. Such crops are much more likely to be established on a permanent basis by farmers who can assure themselves of an ordinary living from cotton or other staple products than by farmers entirely dependent on the sale of cantaloupes, onions, or other precarious specialties.

Yet it would be entirely unreasonable to expect that all of the present settlers in the Southwest will become successful cotton farmers. Many have not engaged in farming except as a speculation and in the hope of sudden wealth from bonanza crops. They have not adopted agriculture as a chosen occupation or as a life which they prefer. The intention may be merely to hold on until the community has passed through the pioneer period and then to sell their land at a price that will enable them to find a more congenial existence in town. Another element of the population comes to the Southwest in search of health rather than to undertake farming. Some of these health seekers have financial resources and are not obliged to make a living from the land on which they settled. It seems very strange in some of these southwestern settlements to find so few able-bodied men on the land. But it often happens that men who come to the Southwest as invalids are brought to study the problem of adapting themselves to the country more carefully than their neighbors and become especially useful citizens. In view of the nature of the resident population it may be reckoned as one of the advantages of cotton that it can employ the labor of those who are not strong enough for other kinds of farm work.

Compared with most of the crops that have been proposed for the Southwest, cotton affords a surer return with a smaller demand of heavy labor. The chief difficulty and expense in raising cotton lie in the picking, but the labor is not severe or exacting as to the time when it must be done. As a family crop for people who do their own work and have some assistance from their wives and children, cotton could hardly be excelled. The harvest season extends over three or four months, or even longer, so that much spare time can be used to advantage in picking cotton. The planting of cotton as a supplementary crop or for the small farmer is limited, of course, to districts where ginning facilities exist, but in all such communities cotton may be expected to contribute a large share to the local prosperity.

The development of cotton culture may be expected to stimulate the growth of many other industries in the Southwest, both agricultural and commercial. The most serious handicap of the cotton

industry at the present time is the scarcity and high price of labor, but the completion of the Panama Canal is expected to increase the labor supply by direct immigration from Europe. Another possibility of the future is the establishment of cotton mills in Los Angeles or other cities of southern California, where enormous supplies of electric power are soon to be available, as well as increased facilities for irrigation. This combination of power and water in the mild climate of southern California may be expected to stimulate a rapid development of manufactures, because the laboring population will be able to reduce living expenses and supplement its earnings by garden products that can be grown throughout the year. Thus, the development of a local market for the southwestern cotton crop can no longer be considered improbable.

SPECIAL REQUIREMENTS OF COTTON CULTURE IN THE SOUTHWEST.

To meet the present high cost of labor and transportation it is necessary to produce cotton that can be sold at higher prices than the ordinary short-staple cotton raised in the older parts of the cotton belt. Experiments have shown conclusively that cotton of high quality, both Egyptian and long-staple Upland, can be raised on the irrigated lands of the Southwest, but at the same time it has become apparent that the methods of farming now followed in most of the southwestern communities are too desultory and unskillful to warrant a hope of realizing the full possibilities of cotton culture. The Salt River Valley of central Arizona is the only district now ready to undertake the production of Egyptian cotton on a commercial scale. In the Imperial Valley of southern California several thousand acres are planted with Durango cotton, a new long-staple Upland type, recently acclimatized from Mexico.

Highly specialized systems of cotton culture are not likely to be developed or maintained in communities where the people are too careless or too little interested to learn how to live and work under the new conditions in which they have placed themselves. It is true that many of the present landholders of the Southwest do not think of themselves as permanent settlers, but expect to make their profits from the sale of their property rather than from raising crops. But even from the standpoint of real-estate values it is highly desirable that the agricultural possibilities of the region be developed.

To take any full advantage of the favorable southwestern conditions, long-staple cottons, either Egyptian or Upland, must be grown, which means that more skillful farming is required than for the production of short staples. This is not because the long-staple varieties are more difficult to raise but because of the higher requirements

of uniformity in long-staple cottons. To secure uniformity two kinds of precautions are necessary. The seed that is planted must come from a uniform stock, and the plants must be grown under uniform conditions. The latter requirement is more easily met, of course, where water can be supplied by irrigation than where the crop is dependent upon rain, but successful irrigation farming requires special knowledge and skill to understand the requirements of the crop and to apply water to the best advantage. There is a very general tendency in irrigated districts to use too much water and to neglect other cultural requirements. The result is that there is usually a very wide discrepancy between the actual results of irrigation farming and those that are sometimes obtained when better methods are used.

COTTON, A HOT-WEATHER CROP.

Cotton is a summer crop and has to be cared for through the hottest months of the year. This fact gives a direct agricultural bearing to the question of how the farmers who are to raise the cotton are to live through the heated term. Though the high temperatures are not as uncomfortable in the dry climate of the Southwest as people from humid climates expect, the summer season involves a strain that some are unable to withstand. The utilization of cotton or any similar crop is likely to depend very largely on the ability of the farmer and his family not merely to exist and preserve a land title through the summer but to live in a normal manner, so that the necessary attention to crops can be given. It is quite as necessary that the farmer learn how to adapt himself to climatic conditions as to plant the right crops or to care for them in the right way.

If it is not possible for the farmer to live and work through the summer without too much hardship or danger to the health of himself and his family, the raising of cotton can not be advised, or even the occupation of the land by people who are to depend on such crops for a living. Questions of housing, rest, and food for the farmer and his family are of agricultural importance no less than the needs of the animals and plants that are raised on the farm. Even the animals have to be spared from labor and protected from overheating when the weather gets too hot. In the eastern part of the cotton belt efforts are being made to induce the farmer to give better housing to his cotton bales, instead of leaving them out to be damaged by wet weather. But in the Southwest it is the farmer and his family who need better housing to afford protection against the hot weather that otherwise interferes too much with agricultural activity.

The use of the farmer's personal resources of health and strength needs to be considered, as well as the results of different expenditures

of time and money that receive such careful determination in the interest of agricultural improvement. That a farmer may have the physical strength to work through the southwestern summer does not prove that it is good policy for him to use his energies in this way in merely resisting exposure to adverse conditions which could be avoided in other ways. Men who are living near the margin of physical endurance are not in condition to use the intelligent care and discrimination that are needed to handle their crops to the best advantage or to undertake such work as the selection and roguing of seed fields, which are among the necessities of successful cotton culture.

It is true that most of the heavy labor of cotton culture, the plowing, planting, and cultivation, is done in the spring before the heated term begins, but the later cultivation, thinning, and roguing may need to be attended to in hot weather, when irrigation becomes especially important. The crop must have the attention that it needs, as well as the labor. Indeed, the labor may easily fail of the proper result if other precautions are neglected, and the danger of neglect is greatest in hot weather.

THE AGRICULTURAL IMPORTANCE OF THICK-WALLED HOUSES.

Even the simplest precaution of securing protection against heat by using thick-walled houses has been almost entirely neglected. The fact that the winters are not severe has been taken to mean that light, thin-walled wooden structures are sufficient, as they are in the equable climate of the coast of California. In this, as in many other respects, the experience of other hot, dry regions of the world has been almost completely ignored in the Southwest. Buildings with thick walls, either of masonry or adobe, are found in some of the towns that date back to the period of Spanish or Mexican colonization, but the value of such buildings as a means of protection against extreme heat seems to have been left out of account almost entirely in the settlements that have been made in recent decades. It does not occur to a progressive American farmer to imitate his more backward Mexican neighbors or to suppose that the Mexican methods of building can be superior in any way to his own.

The chief value of thick-walled houses in warm climates is that they enable rest to be taken in the middle of the day when it is too hot to work. With the temperature above 100° F., refreshing sleep or other forms of rest or recreation become impossible. It is easy to fall into a feverish stupor which leaves one dazed and relaxed, and often with a headache that continues for the remainder of the day. When the air is heated to these extreme temperatures one suffers no more out in the sun, where the perspiration evaporates more rapidly and keeps the skin cooler. Men who are able to work through

the day in the field find it less uncomfortable than to stay in overheated houses. But even this relief is not for the women and children.

In a house with thick walls it is possible to have rooms that remain comparatively cool during the hot hours of the day. Inner rooms with masonry or concrete floors in contact with the earth, or carried down below the surface, may remain as much as 20 degrees cooler than the outside air. This difference of temperature and the relief from the strong light are conducive to prompt and refreshing sleep. Under such circumstances sleeping in the middle of the day is not to be condemned as a lazy habit or a waste of time, but is a reasonable means of preserving bodily strength and mental activity.

The practical advantage of being able to secure normal sleep in the middle of the day is that work may begin earlier in the morning. The best hours of the day in which field work can be done most comfortably and efficiently are those between 4 and 7 o'clock a. m., hours which nearly all of our southwestern settlers spend in sleeping or eating breakfast. If these hours could be added to the usual forenoon's work more could often be accomplished than in a whole day on the present system. Or if working from 4 o'clock to 11 were not deemed sufficient it would still be possible to add three or four hours more in the afternoon, after sleeping two or three hours in the hottest part of the day. But without provision for normal sleep in the middle of the day the early morning hours must be used for this purpose. Going to bed early in the evening is not a practical alternative, for it may not be cool enough for normal sleep until nearly midnight. Thick-walled houses are also hot in the evening, but ideal sleeping accommodations are afforded by the roofs, in accord with the custom of Bible times still in use in oriental countries.

SUMMER FOOD CROPS TO ACCOMPANY COTTON.

The lack of summer food crops may be taken as another evidence that the problems of agricultural existence in the Southwest have not received attention. Though all the supposed requirements of plant growth, heat, light, and moisture are at hand, the farmer often finds himself with nothing that will afford a wholesome diet during the heated term, and in a land of potential plenty must fall back upon canned goods, with a few high-priced vegetables brought in from the coast.

When proper food is lacking, the difficulties of working through the summer, or even of withstanding the heat, are greatly increased. And when food and shelter alike are deficient or of the wrong kind it is no wonder that even the most active pioneer may lose some

of his enthusiasm before the summer is over and conclude that his neighbors are not so far wrong in wishing to sell out and move back East to the coast. Such defeats and disappointments are inevitable unless settlers can be warned in advance and understand that they must provide themselves with new agricultural weapons in the way of special crops and methods of growing them, if they are to overcome the difficulties and enter into permanent possession of the agricultural resources of the southwestern country.

The agricultural possibilities of the Southwest are only faintly suspected on the basis of the few crops now raised; likewise the possibilities of making existence enjoyable in places that now seem hopeless deserts. The present methods are not only inadequate, but are often actually destructive, as when the use of too much water brings up alkali that might otherwise lie harmless in the lower layers of the soil. Methods of extensive farming, proper enough in other parts of the United States, are being used, to the general neglect of the much more important possibilities of intensive farming. The idea that a family can live well and accumulate a competence on a small farm of 5 or 10 acres, as so often stated in prospectuses of irrigated lands, is not to be realized without radical changes of methods. Even the present system of sending supplies of irrigation water through earth canals, at intervals of a week or longer, may prove inadequate for the desired results. Cement channels to afford continued supplies of water may prove economical in the end in spite of their great initial cost. There is an immense waste of water as well as of land in the present system of earth ditches. These are not engineering questions alone, but must be considered ultimately from the standpoint of the farmer and his crops. There can not be farmers without crops or crops without farmers.

Perhaps the best way to think of the possibilities of agricultural development is to remember that an irrigated district in a desert is an oasis and that the plants that have thriven in the Southwest, the cotton, alfalfa, date palms, olives, pomegranates, etc., are those that have come from other dry countries where irrigation is practiced, in Africa and Asia, instead of from other parts of the United States or from Europe. Many other crops, and especially food plants, that are raised under irrigation in other countries have yet to be established in the Southwest.

A further consideration is that many of the oasis food crops are not raised by the methods now used in the Southwest, where it is customary to plant everything out in the sun, but as subcultures, that is, under the partial shade of date palms or other trees, so that the exposure to heat and light is somewhat reduced. The subculture

system, which is also used with many tropical crops, might be described as the reverse of the dry-farming system. The object is not to get the plants farther apart, so that they can draw for water upon a larger area of ground, but to protect them against excessive transpiration by keeping them closer together. Under irrigated conditions the water supply is no longer the limiting factor of plant growth, but the excessive transpiration that results from exposure to the sun. That any crops will grow better under the shade of trees than out in the open ground seems a very absurd idea to the eastern farmer, but such facts are very likely to have practical importance in the agricultural development of the Southwest and experiments along many new lines will be needed before it can be said that the agricultural possibilities of this region have been determined.

CONCLUSIONS.

A new cotton industry is coming into existence in the Southwestern States. The dry climate affords protection against the boll weevil and many other insect enemies and diseases that often reduce or destroy the cotton crop in the East. The absence of wet weather in the harvest season also allows the western cotton to be gathered and sent to market in better condition. These are important advantages and go far toward counteracting the higher cost of labor and transportation. But the agricultural development of the Southwest is attended by several difficulties that must be surmounted before any very extensive utilization of the natural resources of cotton production can be expected.

The agricultural possibilities of the region are not yet appreciated, and the agricultural population is still very small. Many of the present settlers have not come to engage in farming as a permanent occupation, but are in search of health or of profits to be realized by a rapid increase of the value of real estate on the irrigation projects. The presence of this temporary population, not adapted to agricultural work or definitely interested in agricultural problems, makes it more difficult to secure an effective community development of cotton culture or other specialized industries. Cotton of high quality must be grown if the crop is to be profitable, and this requires the presence of an intelligent, efficient agricultural population.

Another obstacle to the progress of cotton culture in the Southwest lies in the fact that the present methods of living and work are not well adapted to the climate. Many of the settlers are unable to work or to stay on their farms during the extreme heat of the summer, and those who remain subject themselves and their families to a test of endurance that often ends in disaster and discouragement.

In the interest of agricultural progress, as well as for other reasons, these conditions must be improved. A better system of house construction is needed to give shelter from high temperatures and make it possible to sleep or rest in the middle of the day and utilize the cooler hours of the early morning for field work.

The health and efficiency of the farming population are also likely to depend to a considerable extent upon the introduction and use of new plants able to grow through the summer in spite of the extreme conditions that are fatal to most of the food plants, fruits, and ornamentals raised in other parts of the country. The irrigated districts of the Southwest are in reality new oases in the desert, and their possibilities of development should be investigated from this point of view. To settlers from other parts of the United States, or even from Europe, the southwestern conditions are altogether new, and we need to profit by the methods and the crops that have been developed in other desert countries to a much greater extent than has appeared thus far.

[Cir. 132]

MOSAIC COHERENCE OF CHARACTERS IN SEEDS OF MAIZE.¹

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In the progeny of crosses between individuals that differ in a number of characters there is often a tendency for the original combinations of characters to remain together instead of being distributed indiscriminately. This tendency for groups of characters represented in the parents to reappear has been recognized as a factor of heredity and is called "coherence." Hybrids between Egyptian and Upland cotton afford a good example of the coherence of characters. The corolla of Egyptian cotton is tubular in form and yellow in color. The flowers of Upland varieties are white and have a more open, cuplike form. Among hybrids between these two types yellow-flowered plants almost invariably have the flowers tubular and show other Egyptian characters. Yellow flowers that are spreading or white flowers that are tubular are of very rare occurrence.² There is thus said to be a coherence between the color and form of the corolla and in this instance the coherence is nearly perfect.

Coherence of characters has usually to be determined by statistical methods, it being necessary to examine a large number of hybrid individuals to determine whether certain combinations occur more frequently than the laws of chance would indicate. In hybrids between Chinese maize with waxy endosperm and our common varieties with horny endosperm there is a definite tendency for the particular combinations of endosperm texture and aleurone color that existed in the parents to persist and reappear in a relatively large percentage of the progeny. This partial coherence of characters has been found without exception in the progeny of the 100 or more crosses that have been examined.

To demonstrate a coherence of this nature it is necessary to separate the seeds into the two classes, colored and white. If there is found to be a significant difference between the percentage of waxy seeds in the two groups there is a correlation. If the largest percentage of waxy seeds is found in the group having the same aleurone color as the waxy parent the correlation is a coherence.

¹ Issued July 19, 1913.

² Cook, O. F. Suppressed and intensified characters in cotton hybrids. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 147, p. 17, 1909.

While these numerical relations adequately demonstrate the reality of the phenomenon, it is not without interest to find cases in which the tendency to coherence is manifested in another and more direct way.

Aleurone color, while in general alternative in its inheritance, often appears in the form of a mosaic, the colored spots varying from almost the entire surface of the seed to the contents of a single cell. The texture of the endosperm is more uniform in its behavior, mosaic inheritance being very rare. In classifying upward of 100,000 seeds only 8 have been observed in which the texture of the endosperm was not uniform throughout the seed. In two of these seeds which showed a mosaic endosperm the aleurone color also appeared in spots and in both of these seeds the mottling of the two characters coincided.

The fact that the spots of aleurone color and the segments of a different endosperm texture corresponded was first noticed by Mr. O. F. Cook in a seed from an ear (Dh359) that resulted from pollinating a plant of the Chinese variety having waxy endosperm and colored aleurone with pollen from a white variety having the ordinary horny endosperm. The aleurone color of the Chinese variety is almost completely recessive to the white of the Gracillima variety with which it was here crossed, and the majority of the seeds were without color. The remainder showed aleurone color in spots of varying size. With the exception of the single seed in question all the seeds of Dh359 were horny, waxy endosperm, being recessive to all other forms of endosperm. In this one seed there was a small waxy area directly beneath a spot of aleurone color and corresponding to it in shape.

The coincidence of the boundaries of the colored spot and waxy area are so exact that the idea of the superposition being the result of chance can not be entertained.

The second example of mosaic coherence occurred in the second generation of Dh209, a cross between a white waxy strain of Chinese and a colored sweet variety.¹ In one of the seeds of this ear the endosperm was waxy except a portion comprising about one-fourth of the seed, which was horny. The waxy portion was overlaid by a white or colorless aleurone, while the aleurone over the horny portion of the endosperm was a deep purple.

In both of these mosaic seeds it will be noted that the association of characters is the same as in the parental strains. Thus, in the first example the Chinese parent having the waxy endosperm had a colored aleurone and in the mosaic seed the waxy portion is overlaid

¹ For a discussion of these hybrids, see Collins, G. N., and Kempton, J. H., Inheritance of waxy endosperm in hybrids with sweet corn, U. S. Department of Agriculture, Bureau of Plant Industry, Circular 120, pp. 21-27, 1913.

by a colored aleurone. In the second example, the waxy parent was white and in the mosaic seed from this cross the waxy portion of the seed is white. In both seeds the form of the colored spot is irregular and the line separating the two kinds of endosperm follows the irregular margin of the spot with great precision.

In the second example, Dh209, the tendency for the white and waxy characters to be associated is also shown in the usual way by the relative numbers of seeds in the different classes. The ear had 561 seeds. Aside from the mosaic seeds these were readily separated into six perfectly distinct classes, as follows: Colored horny, 295; white horny, 42; colored sweet, 101; white sweet, 34; colored waxy, 35; white waxy, 53. Considering the entire ear, 23 per cent of the seeds are white, but of the 88 waxy seeds 60.2 per cent are white.

It might be urged that the correlation shown in the mosaic seeds is physiological. There may be some physiological or chemical reason why a colored aleurone conduces to the development of a waxy texture in the endosperm immediately beneath it, or the waxy endosperm might react on the aleurone immediately above it in a way to produce color. But the fact that the coherence is between colored aleurone and waxy endosperm in one example and between colored aleurone and horny endosperm in the other renders any strictly chemical explanation inadequate.

The Mendelian conception of coherence or gametic coupling is that attractions or repulsions exist between character determinants, causing certain combinations in the gametes to occur more frequently than others. This explanation can not be applied to examples of mosaic coherence, since in the case that represents the first-generation hybrid (Dh359) the segregation has not yet taken place. If we are to venture into this dangerous field of speculation it seems more reasonable to think of the parental gametes as being imperfectly combined, the two parts of the seed falling under the influence of different parents.

Whatever may prove to be the cytological explanation, these mosaic seeds make the phenomenon of coherence appear more tangible and direct by affording a visible example.

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